Plan revision number: Revision 0
Plan revision date: December 2023

CLASS VI PERMIT APPLICATION NARRATIVE
40 CFR 146.82(A)

West Bay Storage Facility

Permit Number: R06-TX-0014

December 2023

TABLE OF CONTENTS

LIST OF TABLES

[redacted]

[redacted]

LIST OF FIGURES

[redacted]

LIST OF APPENDICES

Appendix A Summary of Requirements
Appendix B Area of Review and Corrective Action
Appendix C Financial Responsibility
Appendix D Pre-Operational Testing
Appendix E Testing and Monitoring Plan and Quality Assurance and Surveillance Plan
Appendix F Injection Well Plugging
Appendix G Post-Injection Site Care and Site Closure Plan
Appendix H Emergency and Remedial Response Plan
Appendix I Stimulation Program
Appendix J Injection Well Construction

LIST OF ACRONYMS

Acronym	**Definition**
ΔP_{crit}	critical pressure
μL/L	microliter per liter
1D	one-dimensional
3D	three-dimensional
Amph B	*Amphistegina B*
AOD	Above Ordinance Datum
AoR	Area of Review
APHA	American Public Health Association
API	American Petroleum Institute
APWD	annulus pressure while drilling
BEG	University of Texas at Austin Bureau of Economic Geology

Acronym	Definition
bgs	below ground surface
BOP	blowout preventer
BP	BP Carbon Solutions LLC
BTC	buttress threaded and coupled
BTU/ft.hr.F	British thermal unit per foot hour Fahrenheit
BUQW	base of useable quality water
C&CM	Crisis and Continuity Management
C&EA	Communications and External Affairs
CA	corrective action
CCS	carbon capture and storage
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CO_2	carbon dioxide
COC	chain-of-custody
CWA	Clean Water Act
DAS	distributed acoustic sensing
DTS	distributed temperature sensing
ECD	equivalent circulating density
EDR	Environmental Data Resources
EOC	Emergency Operations Center
EoS	Equation of State
EPA	United States Environmental Protection Agency
ERRP	Emergency and Remedial Response Plan
ESA	Endangered Species Act
ESS	equilibrium-specification-saturation
ft	feet
FIT	formation integrity test
ft/day	feet per day
ft^2/day	square feet per day
ft^3/day	cubic feet per day
g/cm^3	grams per cubic centimeter
GAU	Groundwater Advisory Unit
GC-MS	gas chromatography mass spectrometry
[redacted]	
GIS	geographical information system
GR	gamma ray
[redacted]	
H_2O	water
HSE&C	Health, Safety, Environmental, and Carbon
IC	Incident Commander
ICS	Incident Command System
IHWCA	Industrial and Hazardous Waste Corrective Action
IMP	Incident Management Plan
IMT	Incident Management Team
IP	Individual Permit
IROC	Intelligence and Response Operations Center
IWOB	integrated weight on bit
lbs/ft	pounds per foot
LWD	logging while drilling
M	magnitude
MCL	maximum contaminant level
mD	milliDarcy

Acronym	Definition
MDT	Modular Formation Dynamic Tester
meq	milliequivalents per liter
mg/L	milligrams per liter
mg/kg	milligrams per kilogram
mi^2	square mile
MICP	mercury injection capillary pressure
MIT	mechanical integrity testing
MPa	megaPascal
Mpsi	million pounds per square inch
ms	millisecond
MSL	mean sea level
MS/MSD	matrix spike/matrix spike duplicate
MSRC	Marine Spill Response Corporation
MRT	multi-rate test
Mt	million metric tons
Mtpa	million metric tons per year
MWD	measurement while drilling
N/A	not applicable
n/r	not recorded
NACE	National Association of Corrosion Engineers
NaCl	sodium chloride
$NaClHCO_3$	sodium chloride bicarbonate
NAVD 88	North America Vertical Datum 1988
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NWP	Nationwide Permit
P&A	plugging and abandonment
PBR	Permits by Rule
PFO	pressure fall-off
PHREEQC	pH Redox Equilibrium (in C language)
PISC	post-injection site care
PQL	practical quantitation limits
ppf	pounds per foot
PPFG	pore pressure fracture gradient
ppm	parts per million
PR	Peng-Robinson
PRF	plutonic rock fragment
psi	pounds per square inch
psi/ft	pounds per square inch per foot
psig	pounds per square inch gauge
PTA	pressure transient analysis
PVT	pressure-volume-temperature
PVTX	pressure, volume, temperature, composition
QA	quality assurance
QA/QC	quality assurance/quality control
QASP	Quality Assurance Surveillance Plan
RCA	routine core analysis
RCRA	Federal Resource Conservation and Recovery Act
RHOB	bulk density well log
RMS	root mean square
ROP	rate of penetration
RPD	relative percent difference

Acronym	Definition
RRC	Railroad Commission of Texas
RST	Reservoir Saturation Tool
RSWC	rotary sidewall core
RT PPFG	real time pore pressure fracture gradient
SAPT	standard annulus pressure test
SCAL	special core analysis
SEM	scanning electron microscope
SGR	Shale Gouge Ratio
Site	West Bay Storage Facility
SME	subject matter expert
SOP	standard operating procedure
SPWLA	Society of Petrophysicists and Well Log Analysts
SRF	sedimentary rock fragment
SRT	step rate test
t/d/well	tons per day per well
TAC	Texas Administrative Code
TBD	to be determined
TCEQ	Texas Commission on Environmental Quality
TD	total depth
TDS	total dissolved solids
TPDES	Texas Pollutant Discharge Elimination System
TVDSS	true vertical depth sub-sea
TWDB	Texas Water Development Board
UIC	Underground Injection Control
USACE	United States Army Corps of Engineers
U.S.C.	United States Code
USCG	United States Coast Guard
USDW	underground source of drinking water
USFWS	United States Fish and Wildlife Services
USGS	United States Geological Survey
VLE	vapor-liquid equilibrium
VOC	volatile organic compound
VRF	volcanic rock fragment
VSH	volume shale
WHO	World Health Organization
XRD	X-ray diffraction
XRF	X-ray fluorescence

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CLASS VI PERMIT APPLICATION NARRATIVE
40 CFR 146.82(A)

West Bay Storage Facility

1 FACILITY INFORMATION

Facility Name: West Bay Storage Facility

Facility Contact: [redacted]
501 Westlake Park Blvd., Houston, Texas 77079
[redacted]

Well Location: Galveston County, TX

[redacted]

1.1 Project Background and Contact Information (40 CFR 146.82(a)(1))

BP Carbon Solutions LLC (BP) is submitting a Class VI Injection Well Permit application (Application) for the West Bay Storage Facility (Site), a carbon capture and storage (CCS) project located in Galveston County, Texas. Geological storage of the carbon dioxide (CO_2) at the Site will be in strata of the Fleming Group (Lower Miocene). The supporting documentation associated with this Application was prepared in accordance with the U.S. Environmental Protection Agency's (EPA) Underground Injection Control (UIC) Program for Carbon Dioxide Geologic Sequestration Wells codified in Title 40 of the Code of Federal Regulations [40 CFR 146.81, et seq.] and the EPA's provided templates and guidance documents. A summary of these documents and their respective appendices is as follows:

- Appendix A – Summary of Requirements Class VI Operating and Reporting Conditions
- Appendix B – Area of Review (AoR) and Corrective Action Plan
- Appendix C – Financial Assurance Demonstration
- Appendix D – Pre-Operational Testing
- Appendix E – Testing and Monitoring Plan and Quality Assurance and Surveillance Plan (QASP)

- Appendix F – Injection Well Plugging Plan
- Appendix G – Post-Injection Site Care and Site Closure Plan
- Appendix H – Emergency and Remedial Response Plan
- Appendix I – Stimulation Plan
- Appendix J – Injection Well Construction

[redacted]

BP drilled an appraisal well (Nonagon #1) on August 22, 2022, to evaluate the geological formations at the Site and to provide site-specific data used in this Application. The well was permitted by the Railroad Commission of Texas (RRC); API 4216731543 and Permit Number 878556 were assigned. For construction of the access road and pad for the well, BP acquired a Floodplain Permit, Oil and Gas Permit, and Fill Grade Permit from the City of Hitchcock. A Nationwide Permit 33 was utilized for temporary and permanent fill within wetlands for the road and pad construction. Additionally, a water well (Permit No. WP-486-1105) was permitted but not constructed through the Harris-Galveston Subsidence District (HGSD).

Development of the Site contemplates permitting and construction of injection well pads, associated infrastructure and equipment, and pipeline development. BP has developed a permitting matrix for current and potential permitting requirements for the Site. As specific permits and requirements are confirmed applicable or inapplicable, BP will provide the UIC Program Director with an updated list. Currently, aside from this Application, additional permits and authorizations required for the Site under the programs listed in 40 CFR 144.31(e)(6) include those summarized above. Permits and authorizations that may be required for the Site are summarized in **Table 1.1** below:

Table 1.1. Summary of Potential Permits and Authorizations Required for the Site

Permit or Approval	Project Phase	Authorizing Agency
Federal		
Section 404 of the Clean Water Act (CWA): Nationwide Permit (NWP) or Individual Permit (IP)	Pre-construction	United States Army Corps of Engineers (USACE) - Galveston District
Section 404 of the CWA: NWP 6	Pre-construction	USACE - Galveston District
Regional General Permit (SWG-1998-02413): Horizontal Directional Drill under Navigable Waters of the United States	Pre-construction	USACE - Galveston District
Section 10 of the Rivers and Harbors Act	Pre-construction	USACE - Galveston District
Jurisdictional Determination	Pre-construction	USACE - Galveston District
Compensatory Wetland Mitigation - Compliance with Section 404 of the CWA	Pre-construction	USACE - Galveston District
Section 408 of the CWA	Pre-construction	USACE - Galveston District
Real Estate Outgrant	Pre-construction	USACE - Galveston District
National Environmental Policy Act	Pre-construction	Council on Environmental Quality
Obstruction Evaluation / Airport Airspace Analysis	Pre-construction	Federal Aviation Administration
Compliance with The Endangered Species Act (ESA), Section 7 Consultation	Construction/ Operation	United States Fish and Wildlife Services (USFWS)
Compliance with the ESA, Section 10 Incidental Take Permit for Threatened and Endangered Species	Construction/ Operation	USFWS
Migratory Bird Treaty Act Compliance	Construction/ Operation	USFWS
Bald and Golden Eagle Protection Act Compliance	Construction/ Operation	USFWS
Spill Prevention, and Control and Countermeasures Plan	Construction/ Operation	EPA
State Permits and Approvals		
Coastal Management Program Consistency Statement	Pre-construction	Texas General Land Office (GLO)
State Land Use Lease	Pre-construction	GLO
Stormwater Construction General Permit TXR150000	Pre-construction	Texas Commission on Environmental Quality (TCEQ)
Air - Case-By-Case Minor New Source Review Permit	Pre-construction	TCEQ
Air - Permits by Rule (PBR)106.472 Organic and Inorganic Liquid Loading and Unloading.	Construction	TCEQ
Air PBR 106.511 Portable and Emergency Engines and Turbines	Construction	TCEQ
Air - Prevention of Significant Deterioration Permit and/or Nonattainment New Source Review Permit	Pre-construction	TCEQ/EPA

Permit or Approval	Project Phase	Authorizing Agency
Seismic Survey	Pre-construction	RRC
Pipeline Pre-construction Report	Pre-construction	RRC
Right of Way Permits (May include road construction-entrance, utility installations, and highway use permits)	Construction	Texas Department of Transportation
Drilling Completion Report	Construction	Texas Water Development Board (TWDB)
Water - Temporary Water Rights (TCEQ-20425)	Construction	TCEQ
Water - Temporary Water Rights (TCEQ-10202)	Construction	TCEQ
National Historic Preservation Act of 1966, as amended (16 United States Code [U.S.C.] 470 et seq.) Section 106 Review	Construction	Texas Historical Commission, also referred to as the State Historic Preservation Office
Threatened, Endangered, and other State-Protected Species Consultation	Construction	Texas Parks and Wildlife Department
401 Certification Discharge Dredged or Fill Material (submitted via a Tier I or Tier II Checklist/Questionnaire with USACE Section 404 permit application)	Construction	TCEQ
Water - Hydrostatic Test Water General Permit TXG670000	Construction	TCEQ/RRC
Air - Title V Site Operating Permit	Construction/ Operation	TCEQ/EPA
Water - Texas Pollutant Discharge Elimination System (TPDES) Multi-Sector General Permit TXR050000 or TPDES General Permit TXG11000	Operation	TCEQ
Water - CWA Section 402 - National Pollutant Discharge Elimination System (NPDES)/TPDES for Industrial Wastewater Discharges and Wastewater Treatment Evaluations	Operation	TCEQ
Waste - Industrial and Hazardous Waste Registration	Operation	TCEQ
Hazardous Materials Title 49 CFR Part 107, Subpart G (107.601-106.620)	Operation	TCEQ/TXDOT
City and County Permits and Approvals		
Floodplain Permit	Pre-Construction	[redacted]
Oil & Gas Permit	Pre-Construction	
Fill Grade Permit	Pre-Construction	
Floodplain Development Permit	Pre-Construction	Galveston County
Drainage Facility Crossing Permits	Pre-Construction	Galveston County
County Road Crossing Permit	Pre-Construction	Galveston County
Water Well	Pre-Construction	HGSD

A summary of the proposed operating conditions and routine shutdown procedures can be found in **Appendix A** (Summary of Requirements).

Neither an injection depth waiver nor an aquifer exemption expansion is being requested. At the time of this application, an alternative Post-Injection Site Care (PISC) and Site Closure Plan timeline is not proposed. There are no federally recognized Native American tribal lands or other federally owned territories within the AoR.

The operator of the Site is BP Carbon Solutions LLC, a private company. The contact for the project is [redacted]. Mailing address: 501 Westlake Park Blvd., Houston, Texas 77079.[redacted]

The standard industrial classification code is 8999, Services, Not Elsewhere Classified.

BP has identified the following Texas contacts in accordance with 40 CFR 146.82(a)(20):

- RRC UIC Program: Bryce J. McKee, Phone: 512-463-2259
- TWDB: John Dupnik, Phone: 512-463-7847
- TCEQ: Bryan Smith, P.G., Phone: 512-239-6466

GSDT Submission - Project Background and Contact Information
GSDT Module: Project Information Tracking ***Tab(s):*** General Information tab; Facility Information and Owner/Operator Information tab Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☒ Required project and facility details ***[40 CFR 146.82(a)(1)]***

2 SITE CHARACTERIZATION [40 CFR 146.82(A)(3, 5, AND 6) AND 40 CFR 146.83]

2.1 Regional Geology, Hydrogeology, and Local Structural Geology [40 CFR 146.82(a)(3)(vi)]

The West Bay Storage Facility is located along the Unites States Gulf Coast near Galveston, Texas. The Gulf Coast is a major petroleum-producing region of the United States. Sea-level oscillations had a major impact on sedimentation and the types of depositional environments that existed within the region. Additionally, fluctuations in clastic sediment supply associated with uplift and erosion of nearby mountain ranges, fluctuating channels and drainage systems, changes in basin structure, and salt tectonics greatly affected sedimentation within the region. The Gulf of Mexico Basin and surrounding region within the U.S. Gulf Coast were originally formed because of crustal extension and expansion of the seafloor associated with the breakup of Pangea during Mesozoic time (Sawyer et al., 1991, as cited in Galloway, 2008). The main depocenter of the Gulf Coast region, which is thought to underlie the southern Louisiana coastal plain and adjacent continental shelf, contains as much as 65,600 feet (ft) of rock that accumulated from the Jurassic through the Holocene.

This summary focuses on the Early Miocene to Late Oligocene aged Anahuac Formation through the Pleistocene aged Beaumont Formation, that is, the underburden rocks below the injection zone up to the Underground Source of Drinking Water (USDW) reservoirs.

A significant volume of clastic sediments was deposited during the Oligocene, culminating with a significant transgression and subsequent regression that resulted in the deposition of the mud-dominated Anahuac Formation near the end of the Oligocene and into early Miocene. Coarse clastic deposition resumed at the beginning of the Miocene and continued throughout. The underburden rock of the storage complex comprises the Early Miocene to Late Oligocene aged Anahuac Formation (Treviño and Rhatigan, 2017). Both the injection zone and confining zone lie within the Miocene aged Fleming Group. [redacted] Overburden rocks within the AoR belong to the Upper Miocene and the Plio/Pleistocene aged Goliad and Beaumont Formations. **Figure 2.1** shows the stratigraphic column for the West Bay Storage Facility. **Figures 2.2** and **2.3** show strike and dip cross-sections through the West Bay Nonagon #1 appraisal well.

The structural elements of the AoR comprise regionally extensive syndepositional fault systems that are subparallel to the coast and generally dip towards the south-east. These normal growth faults were formed mainly by gravitational failure during rapid sediment loading along an unstable shelf margin and upper slope (Galloway, 2008). [redacted] **Section 2.3** further discusses faults and fractures in the AoR. [redacted]

Salt tectonics also play an important role in the structural development of the Gulf of Mexico. The salt originally formed as bedded evaporites during the Jurassic period and belong to the Louann Formation (Treviño and Rhatigan, 2017). [redacted] **Figure 2.4 (a)** is a map showing the 5-mile, 20-mile, and 50-mile radii from the Nonagon #1 appraisal well, as well as the county boundaries and topographical contours.

The delineation of the AoR is briefly described here for context of figures shown within this document. A more detailed discussion of the AoR delineation can be found in the AoR and Corrective Action Plan (**Appendix B)**. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

2.1.1 Geologic History

The Gulf Coast is a major petroleum producing region of the United States. Prehistoric sea level oscillation significantly impacted the sedimentation and depositional environments that existed within the region. Additionally, fluctuations in clastic sediment supply associated with the uplift and erosion of nearby mountain ranges, fluctuations in channels and drainage systems, changes in basin structure, and salt tectonics affected the geological development of the region (Treviño and Rhatigan, 2017).

The Gulf of Mexico Basin and greater Gulf Coast were originally formed from crustal extension and seafloor expansion associated with the breakup of Pangea during the Mesozoic Era (Sawyer et al., 1991, as cited in Galloway, 2008). The main depositional center in the Gulf Coast, which has been inferred to underlie the southern coastal plains of Louisiana and the adjacent continental shelf, potentially contains up to 65,600 ft of rock that accumulated from the Jurassic Period through the Quaternary Period (Holocene Epoch). During the Tertiary Period, large quantities of sand and mud were deposited along the margins of the Gulf of Mexico. The Gulf Coast sediments were deposited in fluvial-deltaic or shallow-marine environments. Repeated sea-level changes, basin subsidence, and changes in sediment source caused the development of cyclic sedimentary deposits composed of a heterogenous assemblage of sands, silts, clays, and gravels. The depositional environment resulted in a series of pro-gradational wedges, beginning with the underlying Anahuac Formation, the Fleming Group (which contains both the injection and confining zones), and the overlying Goliad and Beaumont Formations.

Numerous growth faults developed parallel to the Gulf Coast during depositional periods, largely controlling sediment accumulation and dispersal patterns (Galloway, 2008). These growth faults are syndepositional and characterized as curved faults that grow with burial depth.

Salt tectonics were significant in the structural development of the Gulf of Mexico, with salt originally forming as bedded evaporites during the Jurassic Period. Salt domes also developed within the Gulf Coast during depositional periods. More common in northern Texas, some salt domes locally penetrate the shallower areas of the Gulf Coast aquifer (Chowdhury and Turco, 2006). Salt bodies, however, do not intrude nor have a major impact on the structure of the storage complex within the AoR. The structural geology of the area is further discussed in **Section 2.1.3** (Geologic Features / Structural Geology).

2.1.2 Geological Setting

Additional stratigraphy within the AoR is present both above and below the injection and confining zones (See **Figure 2.1** (Stratigraphic Column for West Bay Storage Facility)). This stratigraphy surrounding the injection and confining zones may be encountered during Site activities and is further described below.

2.1.2.1 Beaumont and Goliad Formations

Younger stratigraphy of the Beaumont and Goliad Formations are most likely to be encountered at ground level. These rock units are comprised of Plio/Pleistocene and Upper Miocene sediments that contain the water-bearing units in the Gulf Coast aquifer system in Texas, which is the USDW associated with this Site and described further in **Section 2.7** (Hydrologic and Hydrogeologic Information). [redacted] The Goliad unconformably overlays the Fleming Group.

2.1.2.2 Fleming Group

The Fleming Group is described as Miocene-aged sediments [redacted] The Fleming Group comprises the more mud-rich Lagarto Formation (Middle Miocene) and the generally sand-rich Oakville Formation (Lower Miocene). The Fleming Group is overlain by the Goliad Formation and underlain by the Anahuac Formation.

Lower Miocene sediments initially built across and prograded out onto the broad, submerged shelf platform constructed during the Oligocene. The rate of outbuilding slowed as large-scale growth faulting created a narrower Lower Miocene expansion zone. By Middle Miocene, the shoreline was stable to retreating with aggradational and retrogradational deposition (Galloway, 1985). Regionally, the Fleming Group extends laterally throughout the coastal areas of Texas and eastern Louisiana. The Fleming Group outcrops at surface approximately 120 miles north of the AoR and can be seen at depths of more than 6,500 ft true vertical depth sub-sea (TVDSS) just south of the AoR (offshore near Galveston Island). The thickness of the Fleming Group ranges from ~1,000 feet (at outcrop) to ~5,000 ft (near the coast); [redacted]

[redacted] The injection and confining zones are discussed in **Sections 2.1.4 and 2.1.5** respectively.

2.1.2.3 Anahuac Formation

The Anahuac is overlain by the Fleming Formation and underlain by the Frio Formation. The Anahuac Formation is Lower Miocene to Upper Oligocene in age and [redacted]

2.1.3 Geologic Features / Structural Geology

The Texas Gulf Coast can be described as a mainly smooth, low-lying coastal plain that gradually rises from sea level in the south-east to as much as 900 ft in the north and west. The Texas Gulf Coast stratigraphy is comprised primarily of a massive thickness of sediments consisting of interbedded sands and shales. [redacted]

Geological features associated with salt are present in the Gulf of Mexico Basin and have the potential to provide both structural and stratigraphic traps for oil and gas. Salt bodies, however, do not intrude nor have a major impact on the structure of the storage complex within the AoR.

A series of pro-gradational wedges in the Gulf Coast Region consists of the Vicksburg Formation, Frio Formation, Anahuac Formation, Fleming Group, Goliad Formation, and Beaumont Formation. The structure of these units is characterized by large discontinuous growth faults and deep-seated shale ridges. The faults are primarily strike-oriented growth faults that are parallel to the coastline. Generally, these faults are present deeper in the subsurface around depths of 3,200 to 13,000 ft (Chowdhury and Turco, 2006) and affect the lower stratigraphic units (Solis, 1981). These faults have throws that increase with depth and have thicker strata on the downthrown side than on the upthrown side. Sand depocenters commonly form around downthrown fault blocks, providing potential for stratigraphic traps. Stratigraphic traps are also potentially present where sand, mud, or carbonates with enhanced porosity preside below mud or clay with lower porosity (Chowdhury and Turco, 2006).

Structural geology as it relates to faults and fractures is further discussed in **Section 2.3.**

2.1.4 Injection Zone

The injection zone for the Site is within the Fleming Group of the (Lower) Miocene Epoch and the Neogene Period. [redacted] The Fleming Group is regionally overlain by the Goliad Formation and is regionally underlain by the Anahuac Formation. (**Figure 2.1**)

Figure 2.5 shows the thickness contour map of the injection zone in relation to the AoR. [redacted]

[redacted]

[redacted] The injection zone units of the Fleming Group display adequate deep reservoir qualities within the middle and upper Texas Gulf Coast and is expected to be sufficient for CO_2 injection. Further discussion is available on the porosity and permeability of the injection zone in **Section 2.4** (Injection and Confining Zone Details).

2.1.5 Confining Zone

The confining zone for the Site is within the Fleming Group of the (Middle) Miocene Epoch and the Neogene Period [redacted] (See **Figure 2.1** for the Stratigraphic Column for the West Bay Storage Facility). Sediment supply to the Basin during the Lower Miocene was mainly from fluvial systems entering the Basin from the north and northwest. The end of the Lower Miocene is marked by a major transgressive event in the Basin and is defined by the *Amphistegina B* (*Amph B*) biochronostratigraphic zone. The *Amph B* transgression interrupted episodes of sandstone-dominated deltaic and shore-zone progradation near the end of the Lower Miocene and at the beginning of the Middle Miocene (Lu et al., 2017).

This *Amph B* biomarker zone defines the base of the confining zone [redacted] In the central and upper Texas area, nearly all hydrocarbon producing Miocene-age reservoirs underlie the *Amph B*, attesting to its trapping capability (Lu et al., 2017). The *Amph B* zone will act as the first barrier/baffle to vertical CO_2 migration. [redacted]

The top of the confining zone is delineated by the top of the Fleming Group [redacted]

[redacted] **Figures 2.2 and 2.3** show well log correlation sections in strike and dip outlining the top and base of the confining zone. [redacted]

Figure 2.6 shows the thickness contour map of the confining zone in relation to the AoR. Further discussion is available on the porosity and permeability of the confining zone in **Section 2.4** (Injection and Confining Zone Details). The confining zone units of the Fleming Group displays adequate capping quality within the middle and upper Texas Gulf Coast and is expected to be sufficient for CO_2 containment.

2.1.6 Uncertainty

Subsurface geological interpretation comes with uncertainties, and alternative interpretations were taken into consideration. **Section 2.5.5** (Facies Changes – Uncertainties) discusses uncertainties in geological facies distribution and alternative interpretations considered for the geometries of the confining and injection zones. **Section 2.3.3** (Faults and Fractures – Uncertainty) discusses the uncertainties considered in the fault and fracture modeling. [redacted]

2.2 Maps and Cross-Sections of the AoR [40 CFR 146.82(a)(2), 146.82(a)(3)(i)]

See the previous section for descriptions of confining and injection zones, stratigraphic column with general lithologies, and related cross-sections. The following figures are provided as maps and cross-sections that represent the AoR:

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

2.2.1 Project Area Map [40 CFR 146.82(a)(2), 40 CFR 146.84(c)(2)]

BP conducted an extensive search to identify the pertinent features within the AoR, which are depicted in the Project Area Map (**Figure 2.13**) in compliance 40 CFR 146.82(a)(2) and 40 CFR 146.84(c)(2). Searches were conducted for the following features:

a. State and federal subsurface cleanup sites;
b. Surface water bodies;
c. Springs;
d. Mines (surface and subsurface) and quarries;
e. Structures intended for human occupancy; and
f. Artificial penetrations (APs) including producing, abandoned, and plugged wells, Class I, II, III, IV, and V wells, dry holes, and stratigraphic boreholes.

2.2.1.1 State and Federal Subsurface Cleanup Sites

State subsurface cleanup sites were searched within the AoR using the Industrial and Hazardous Waste Corrective Action (IHWCA) database from the TCEQ Environmental Systems Research Institute (ESRI) Geographic Information System (GIS) Data Hub, the TCEQ Innocent Operator Database, and The TCEQ Brownfields Site Assessment database:

- TCEQ Leaking Petroleum Storage Tank[1]
- TCEQ Landfills[2]
- TCEQ Groundwater Conservation Districts[3]
- TCEQ Industrial Hazardous Waste Corrective Action[4]
- TCEQ Innocent Operator Program[5]
- TCEQ Brownfields Site Assessment[6]

One site within the AoR was identified on the IHWCA as having an active corrective action:

[redacted]

In addition to the searches performed above, an Area/Corridor Report was purchased from Environmental Data Resources (EDR). The Area/Corridor Report, dated September 20, 2023, identified environmental registrations within a defined project boundary, which was provided to EDR. The boundary included a quarter-mile offset from the AoR. The report contained a listing

[1] https://gis-tceq.opendata.arcgis.com/datasets/TCEQ::lpst-points/explore?location=30.216820%2C-93.996604%2C10.65&showTable=true
[2] https://gis-tceq.opendata.arcgis.com/datasets/TCEQ::landfills/explore?location=30.340981%2C-93.778136%2C12.00&showTable=true
[3] https://gis-tceq.opendata.arcgis.com/datasets/TCEQ::groundwater-conservation-districts/explore?showTable=true
[4] https://www.arcgis.com/home/item.html?id=40fb57c8e9b84d518e0da8ef360621de
[5] https://www.arcgis.com/home/item.html?id=6605463960ee4ccf96850ab54f599781
[6] https://www.arcgis.com/home/item.html?id=aa9a813390f34fdb96d694fbf68e536d

of State and Federal cleanup sites identified within and near the AoR by searching a range of County, State and Federal databases for sites, including the following: Lists for Federal National Priority List (NPL) (Superfund) sites; Federal Delisted NPL sites, Federal sites subject to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) removals and CERCLA orders, Federal CERCLA sites with No Further Remedial Action Planned, Federal Resource Conservation and Recovery Act (RCRA) facilities undergoing corrective action, Federal RCRA transportation, storage, and disposal facilities, Federal RCRA generators, Federal institutional controls/engineering controls registries, Federal Emergency Response Notification System list, State and Tribal (Superfund) equivalent sites, State and Tribal landfills and solid waste disposal facilities, State and Tribal leaking storage tanks, State and Tribal registered storage tanks, State and Tribal institutional control/engineering control registries, State and Tribal voluntary cleanup sites, State and Tribal brownfield sites, local brownfield lists, local lists of landfill/solid waste disposal sites, local hazardous waste/contaminated sites, local lists of registered storage tanks, local land records, records of emergency release reports, County records, and other databases.

The report was reviewed for records related to subsurface cleanup sites within the AoR. No subsurface cleanup sites were identified within the AoR from the EDR Area/Corridor Report.

2.2.1.2 Surface Water Bodies

Surface water bodies within the AoR were identified using the National Hydrography Dataset (NHD) Flowing Water and NHD Water Bodies GIS layers from the United States Geological Survey (USGS) National Hydrography Dataset, the River Basins GIS layer from the Texas Water Development Board, Texas Tech University Center for Geospatial data for Texas, the Texas National Wetlands Inventory (NWI) geodatabase from the US Fish & Wildlife Service, and the Surface Water Segments database from the TCEQ ESRI GIS Data Hub. These resources can be found at the websites listed below.

- USGS NHD Best Resolution – Texas[7]
- Texas Tech University Center for Geospatial Technology[8]
- U.S. Fish & Wildlife Service NWI Texas Geodatabase[9]
- TCEQ Surface Water: Line Segments[10]
- GIS Data | Texas Water Development Board[11]

A number of surface water bodies within the AoR were identified by the search. [redacted] Surface water bodies are depicted on **Figure 2.13**.

[7] https://www.sciencebase.gov/catalog/item/61f8b8edd34e622189c3293f
[8] https://www.depts.ttu.edu/geospatial/center/TexasGISData.html
[9] https://www.fws.gov/program/national-wetlands-inventory/download-state-wetlands-data
[10] https://gis-tceq.opendata.arcgis.com/datasets/TCEQ::segments-line/explore?location=30.301545%2C-93.974762%2C11.57&showTable=true
[11] https://www.twdb.texas.gov/mapping/gisdata.asp

2.2.1.3 Springs

The AoR was assessed for springs using Data Basin's publicly available Springs of Texas dataset:

- Data Basin Springs of Texas[12]

No springs were identified within the AoR.

2.2.1.4 Mines & Quarries

The AoR was assessed for mines and quarries using the Mineral Resources data layer and the Prospect & Mine Related Features from the following USGS GIS sources:

- USGS Mine Related Features[13]
- USGS Mineral Resources[14]

Historical aerial photographs were also reviewed.

Within the Area/Corridor Report purchased from EDR, multiple mining and quarry regulatory databases were reviewed to identify registrations within the AoR. The databases searched included the following: Uranium Mill Tailings Sites, Lead Smelter Sites, US Mines (Mines Master Index File, Ferrous and Nonferrous Metals Mines Database Listing, Active Mines & Mineral Plants Database Listing), Mines Violations (Mine Safety and Health Administration Violation Assessment Data), and Abandoned Mines.

No mines or quarries were identified within the AoR.

2.2.1.5 Structures Intended for Human Occupancy

The AoR was searched for structures intended for human occupancy using the Brazoria Land Parcels databases of the TNRIS DataHub and Galveston land parcels from the Original Texas Land Survey Statewide Land Grid (RRC Version), the US Census GIS dataset of Texas Population Areas and the Public Schools K-12 dataset from the Texas Tech University Center for Geospatial Technology, and the USGS US Hospitals ArcGIS dataset.

- TNRIS DataHub Land Parcels[15]
- Texas Tech University Center for Geospatial Technology[16]
- USA Hospitals - Overview[17]
- Original Texas Land Survey (OTLS) - Statewide Land Grid (RRC Version)[18]

[12] https://databasin.org/datasets/2400de0b78284e0fa44083e78824ff24/
[13] https://mrdata.usgs.gov/usmin/
[14] https://mrdata.usgs.gov/mrds/
[15] https://data.tnris.org/collection/?c=55eb0be8-6d05-4536-bf75-45f1dd31dd94
[16] https://www.depts.ttu.edu/geospatial/center/TexasGISData.html
[17] https://www.arcgis.com/home/item.html?id=f114757725a24d8d9ce203f61eaf8f75#!
[18] https://www.arcgis.com/home/item.html?id=4ef2ab14e55a406ca68d0c0221f2ef8a

[redacted]

2.2.1.6 Artificial Penetrations (APs)

In accordance with 40 CFR 146.82(a)(4) and 40 CFR 146.84(c)(2), a search was conducted to identify and evaluate all APs, including water wells; producing, abandoned, and plugged wells; Class I, II, III, IV, and V wells; dry holes; and stratigraphic boreholes. To identify all APs, the following searches were conducted:

- BP searched the TWDB and RRC databases, as well as Enverus, a private subscription-based service, using geographic attributes such as county and state-level files to identify APs. Then using ArcGIS, the AoR was overlaid against the identified AP locations, the Select by Location function was performed, and the wells that fell within the AoR were selected and exported as a list.
- An EDR DataMap™ Well Search Report, dated September 20, 2023, provided a listing of the attributes and location coordinates of the oil and gas wells and water wells located within the AoR that are registered with local, state, and federal databases. An accompanying base map depicting the location of each well was included with the report. Each well in the EDR DataMap™ Well Search Report was cross-referenced against the wells identified through the TWDB and RRC databases.
- To identify UIC Class I, III, IV, and V injection wells, the TCEQ Central File Room online records were examined. Cities and zip codes within the counties of the AoR were identified to search the TCEQ database for UIC permits. UIC permits within those city, zip code, and county locations were then cross-referenced for geographical location against the AoR. No UIC Class I, III, IV, or V wells in the AoR were identified during this search.
- RRC records were searched for Class II injection wells, in addition to the EDR DataMap™ Well Search Report. No Class II injection wells were identified.

All APs identified through these methods were combined to create a comprehensive list of APs within the AoR. All APs are depicted in Figure 2.13 with a unique identifying number that corresponds to an AP listed in Table 6 (Listing of All Artificial Penetrations within the AoR) of the Area of Review and Corrective Action Plan (Appendix B).

Once the APs were identified, an exhaustive AP records search was performed and included reviewing databases, reports, maps, logs, and other documents from federal, state, local, and private entities that have information on wells or boreholes in the AoR. Records and databases belonging to the RRC, TCEQ, Texas Department of Licensing and Regulation (TDLR), TWDB, University of Texas at Austin Bureau of Economic Geology (BEG), Harris-Galveston Subsidence District, Enverus, and TGS were reviewed. Limited historical aerial images were also reviewed to support the search. A description of the searches conducted, and the results of those searches, are described below.

RRC

Online research queries within the RRC database and the RRC GIS Viewer were utilized to search the RRC well files (websites listed below). Personnel performed in-person records searches at the RRC Central Records office in Austin to retrieve non-digital data files, including microfilm. Well records for which an online digital record and/or API number was not available required a manual search of RRC Central Records. For these records, a research request was sent to and completed by the RRC Research Team. [redacted] The timeline for the request was estimated to be six to eight weeks for a researcher to be assigned, plus additional time for the researcher to research and send the records. This permit application will be amended with the records requested from RRC Central Records once they are received.

The online RRC resources that were searched included:

- RRC Public GIS Viewer (Map)[19]
- RRC Resources & Research Center[20]
- RRC Online Research Queries[21]
- RRC Imaged Records[22]

Well records were found and have been uploaded as Supporting Documentation under the Corrective Action tab of the Area of Review and Corrective Action reporting module in the Geologic Sequestration Data Tool (GSDT).

TCEQ

The TCEQ was contacted via telephone and email to verify the appropriate search methods for obtaining AP records and for assistance with the search. It was concluded that no digital (hard copy) records for wells in the AoR could be found in the TCEQ's databases or Central Records. In addition, each of the links below were followed and all potentially relevant documents were reviewed. No relevant documents were found with the TCEQ.

- TCEQ Access Records from Central File Room[23]
    - Contacted the TCEQ Central File Room by telephone and email. The Central File Room Team directed the inquiry to the Drinking Water Inventory and Protection Team in the Water Supply Division. It was determined that well records for the wells in this AoR are not available at TCEQ.

[19] https://www.rrc.texas.gov/resource-center/research/gis-viewer/
[20] https://www.rrc.texas.gov/resource-center/
[21] https://www.rrc.texas.gov/resource-center/research/research-queries/
[22] https://www.rrc.texas.gov/resource-center/research/research-queries/imaged-records/
[23] https://www.tceq.texas.gov/agency/data/records-services/fileroom.html

- TCEQ Central Registry Query [24]
    - Searched for Galveston County water wells on TCEQ's Central Registry Query pages including customer search, regulated entity search, program ID search and document search. No relevant documents were found.
- TCEQ Look Up Data and Records Online[25]
    - Searched the water well database raw files and "Water Well Report Viewer." Within the "Water Well Report Viewer", the reports listed below are available. However, no relevant documents for wells in the AoR are included in these reports.
        - Galveston County Data and Information Management System Reports
        - Galveston County Legacy Maps
        - Galveston County Maps and Photos
        - Galveston County Not Plotted Water Wells
        - Galveston County Plotted Water Wells
        - Galveston County Plugging Reports
        - Galveston County State Water Well Reports
        - Galveston County Undesirable Reports
- TCEQ Records Online[26]
    - Searched for listed Galveston County water wells on TCEQ's "Records Online" database. No relevant documents were found.
- TCEQ GIS[27]
    - Conducted searches within the GIS Data Hub, which includes Groundwater Conservation District data. No relevant documents were found. This also links back to the "Water Well Report Viewer".
- TCEQ Finding Information about Water Wells in Texas[28]
    - The link above directs to the "Water Well Report Viewer" and to the TWDB, [redacted]

TWDB

The TWDB was contacted via telephone and email to assist with the search. The agency confirmed that no hard copy files exist, and the web viewer has all files associated with the wells.

[24] https://www15.tceq.texas.gov/crpub/
[25] https://www.tceq.texas.gov/agency/data/lookup-data
[26] https://records.tceq.texas.gov/cs/idcplg?IdcService=TCEQ_SEARCH
[27] https://www.tceq.texas.gov/gis
[28] https://www.tceq.texas.gov/drinkingwater/SWAP/wells.html

- TWDB Submitted Drillers Reports[29]
    - Conducted searches of GIS viewers and databases accessed from this website: Groundwater Data Viewer (Interactive Map), Groundwater Database Report and Downloads, Submitted Drillers Report Database Reports and Downloads. Well data sheets and attachments were found and are included with the well records.
- TWDB BRACS Database[30]
    - The Brackish Resources Aquifer Classification System (BRACS) database was utilized to match API numbers with TWDB numbers for wells which may have been converted from an oil/gas well to a water well or vice versa. [redacted]

TDLR

The TDLR was contacted via telephone and email to assist with the search of these records. The agency responded that they did not have any hard copy files and sent the following website links in response to the request for files:

- TWDB Submitted Drillers Reports
- TCEQ Finding Information about Water Wells in Texas

Both websites were searched for records as described in the TCEQ and TWDB sections above. The TDLR website (https://www.tdlr.texas.gov/wwd/wwd.htm) contains a link for the Texas Well Reporting System, which directs to the TWDB Submitted Drillers Reports Database for wells drilled after 2002. This website was researched as described in the TWDB section above.

BEG

The BEG was contacted via telephone and email to verify the appropriate search methods for obtaining AP records and/or for assistance with the search. The Continuum database (website below) was searched, and any relevant files were purchased if the file was not found by other sources. Although there are hard copy paper records that have not been catalogued at the BEG, it was reviewed and confirmed by BEG staff that no other files are available for the wells in the AoR.

- BEG Geologic Data Continuum[31]
    - Conducted search within the Continuum database. Logs were found and purchased as applicable.

Harris-Galveston Subsidence District

The Harris-Galveston Subsidence was contacted via telephone to verify the appropriate search methods for obtaining AP records and/or for assistance with the search. The HGSD Well Radius Map database (website below) was searched for well information. The plugging record and well information for the well of interest was found by HGSD staff and provided via email.

[29] http://www.twdb.texas.gov/groundwater/data/drillersdb.asp
[30] https://www.twdb.texas.gov/groundwater/bracs/database.asp
[31] https://coastal.beg.utexas.edu/continuum/#!/

- HGSD Well Radius Map (arcgis.com)[32]

Private Databases

Two private subscription-based services were searched for AP records: Enverus and TGS. Enverus stores any publicly available well records, including permit information, drilling, completions, and production-related information and records, as well as raster logs. For the Enverus search, the Prism and DrillingInfo dashboards were utilized to search for well information and any relevant information was saved for the well record as applicable.

TGS stores well data including raster logs and directional surveys. For the TGS search, the R360 platform was utilized to search for well information and any relevant logs were saved for the well record as applicable.

2.3 Faults and Fractures [40 CFR 146.82(a)(3)(ii)]

2.3.1 Evidence for Faults and Fractures

[redacted] The series of pro-gradational wedges in the Gulf Coast Region, which includes the Fleming Group, are characterized by thickening upward sequences and gulfward dips. [redacted] Rapid sedimentation loading during deposition resulted in large growth fault systems near the downdip edge of each wedge. These normal growth faults generally are subparallel to the coast and dip towards the southeast. [redacted]

[redacted]

[32] https://hgsd.maps.arcgis.com/apps/webappviewer/index.html?id=abe6acac88d544fb8ecf22668a5ebf7b

[redacted]

Three major structural areas are identified for the Fleming Group within Texas. These structural areas are defined as the Houston Embayment; San Marcos Arch and southward area towards the Rio Grande Embayment; and the Rio Grande Embayment. [redacted] Salt tectonics were significant in the structural development of the Gulf of Mexico, with salt originally forming as bedded evaporites during the Jurassic Period. Shallow salt domes and turtle structures are present in the surrounding area, [redacted]

2.3.2 Faults and Fractures in the AoR

[redacted]

2.3.3 Uncertainty

BP identified uncertainties in the current AoR model that will be addressed in planned future modeling. [redacted]

2.4 Injection and Confining Zone Details [40 CFR 146.82(a)(3)(iii)]

2.4.1 Injection Zone

2.4.1.1 Mineralogy and Petrology

BP's Nonagon #1 well, drilled in 2022, is the appraisal well for this Site and is located within the AoR (see **Figures 2.10** and **2.11** which show the structure contour maps of the injection and confining zones, respectively). [redacted] This data acquired in the Nonagon #1 well represents the most robust dataset available for any wells within the AoR. It is expected to be representative of the range of geologic conditions at this Site based on the application of the regional understanding for the depositional environment of the Fleming Group and seismic observations away from well control.

Mercury injection capillary pressure measurements will be done on core plugs taken from the rotary side wall cores of the Nonagon #1 well. This testing will cover a wide range of rock facies including both the confining and injection zones, as part of the RCA and special core analysis (SCAL) program. The measurements are still in progress; data will be incorporated into future AoR modeling as appropriate. Capillary pressure is discussed further in **Section 2.5.3** (Capillary Pressure).

[redacted]

[redacted]

[redacted]

Mineralogical data is derived from XRD analyses performed at Core Spec Alliance LLC, Houston, Texas and petrographical analyses (SEM and modal analysis) performed at Stratum Reservoir, Houston, Texas. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

2.4.1.2 Thickness, Porosity, and Permeability

[redacted]

f [redacted] The injection zone of the Fleming Group displays the best deep-reservoir quality within the middle and upper Texas Gulf Coast and is expected to be sufficient for injection and storage of CO_2 because of its suitable depth [redacted] within the CO_2 supercritical window and regional areal extent of deposition.

2.4.1.3 Geochemical Compatibility

[redacted] SEM analysis is key in understanding the subtle diagenetic alteration of these sandstones and is discussed in the Minerology and Petrology description in **Section 2.4.1.1** (Injection Zone Minerology and Petrology).

[redacted] The Fleming Group has an overall framework of alumino-silicate mineral composition, which is resistant to dissolution under low pH conditions, particularly in the zones dominated by quartz. [redacted]

The available reactive surface area is also a primary controlling factor in the forecasts of fluid-rock reactivity. [redacted]

[redacted]

2.4.2 Confining Zone

2.4.2.1 Minerology and Petrology

[redacted] The Fleming Group is described as succession of continental-margin stratigraphy, often fluvial and deltaic, deposited during continental margin growth in the Lower Miocene in South-Central Texas (Eluwa et al., 2018).[redacted]

Mercury injection capillary pressure measurements will be done on core plugs taken from the rotary side wall cores of the Nonagon #1 well. This testing will cover a wide range of rock facies including both the confining and injection zones, as part of the RCA and special core analysis (SCAL) program. The measurements are still in progress; data will be incorporated into future AoR modeling as appropriate. Capillary pressure is discussed further in **Section 2.5.3** (Capillary Pressure).

[redacted] Data collected at the Nonagon #1 well is representative of conditions in the proposed geologic storage facility, as described in **Section 2.4.1.2** (Injection Zone Thickness, Porosity, and Permeability). Mineralogical data is derived from XRD analyses performed at Core Spec Alliance LLC, Houston, Texas and petrographical analyses (SEM and modal analysis) performed at Stratum Reservoir, Houston, Texas. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

2.4.2.2 Thickness, Porosity, and Permeability

[redacted]

[redacted]

2.4.2.3 Geochemical Compatibility

[redacted]

2.4.3 Methods

Porosity was modeled using the fine-scale porosity logs from eleven wells with available porosity data (four with density logs and seven with sonic logs) within the AoR. The log porosity was calculated using the density porosity model where density log data was available. The formula utilized for density is as follows:

[redacted]

Where density log data was not available, sonic log data was used to derive porosity as described below:

[redacted]

In order to estimate permeability in the offset wells within the AoR, porosity-permeability trends were established from core data that BP accessed from the RAPID database (Reservoirs Applied Petrophysical Integrated Data - a worldwide rock catalog from Core Laboratories used to search for reservoir analogues). The core porosity and core permeability relationship established from this data is summarized below:

[redacted]

This poro-perm transform was used to generate the permeability distribution in the static model.

Further information on the modeled porosity and permeability is described in the Area of Review and Corrective Action Plan (**Appendix B**). Additional porosity and permeability data collected from core and logs during pre-operational testing will be used to update the porosity and permeability relationship and property distribution in the static model.

An extensive formation fluid sampling and pressure sampling program was run on the appraisal well Nonagon #1 to assess physical and chemical characteristics of the formation fluids in injection and confining zones. Fluid sample data will be used to understand water chemistry, establish baseline water quality in the confining and injection zones, provide geochemical information on solids and fluids to identify potential interactions that could affect injectivity or mobilize trace elements, and assess compatibility of the CO_2 stream with fluids and minerals in the injection and confining zones. Injectivity and pressure fall-off tests were performed on the appraisal well Nonagon #1 to verify the hydrogeologic characteristics of the injection zone and are described in the Pre-Operational Testing Program (**Appendix D**).

Whole core and rotary sidewall core plugs were acquired across the injection and confining zones in the appraisal well Nonagon #1. Core data was used to provide information on the geomechanical properties, mineralogy, petrology, and lithologies of the injection and confining zones. This data will be used to demonstrate the integrity of the confining zone to provide a barrier to CO_2 leakage, the suitability of the injection zone to safely hold the injected CO_2, and to set safe operational parameters. Further information on core testing and geomechanical methods is discussed in **Section 2.5** (Geomechanical and Petrophysical Information).

2.4.4 Supporting Data for Confining and Injection Zones

2.4.4.1 Seismic Data

BP utilized a 3D pre-stack time migrated seismic reflection dataset to characterize the confining and injection zones. [redacted]

[redacted]

2.5 <u>Geomechanical and Petrophysical Information [40 CFR 146.82(a)(3)(iv)]</u>

2.5.1 Structure and Mechanism of Geologic Confinement

2.5.1.1 Core Testing

[redacted]

[redacted]

2.5.1.2 Fractures, Ductility, Rock Strength, In-Situ Stress Field, Pore Pressure, Hydraulic Gradient, Fracture Gradient

While drilling the Nonagon #1 well, [redacted]

[redacted]

[redacted]

2.5.2 AoR Reservoir Model

[redacted] The AoR is further described in the Area of Review and Corrective Action Plan (**Appendix B**).

Dense phase CO_2 and brine are both accounted for by the model. [redacted]

[redacted]

2.5.3 Capillary Pressure

Before drilling its appraisal well, as part of an initial pre-appraisal analysis, BP relied upon data from a previous injection well. Frio Brine Pilot Test TCEQ Number 5X2500071 injection well was drilled in May 2004, and three conventional cores were cut, one from the Anahuac Shale and two from the C sandstone interval. The results have been published in the Society of Petrophysicists and Well Log Analysts (SPWLA) 2005 Annual Symposium (Sakurai et al 2005). This well is located in Humble Fee Tract 1, approximately 30 miles northeast of Houston, in Dayton, Texas,[redacted] The published core analysis data indicates Frio sand porosity in the range of 11% to 36% and permeability in the range of 0.5 mD to 3,000 mD. The mercury injection capillary pressure test on a core plug from Anahuac Shale interval was reported to have a high entry pressure of 3,500 psi for mercury.

Capillary pressure curves were derived from published empirical values and from using the Van Genuchten model. Irreducible water saturation limits were scaled for two rock types (clean sand and clay-rich silt), and drainage curves were calculated. The imbibition curves were calculated using a fitting exponent to honor a maximum trapped gas saturation of 0.30. Published data based on bead pack experiments were used as the foundation to derive curves for each respective rock type (Jung and Hu, 2016).

Total rock compressibility was included in the model. [redacted] Lithostatic pressure only becomes a significant constraint on compressibility at greater depths.

The appraisal well program includes mercury injection capillary pressure measurements on 30 core plugs obtained by the rotary side wall coring in the Nonagon #1 well in a wide range of rock facies including both the confining and injection zones, as part of the RCA and special core analysis (SCAL) program.[redacted]

2.5.4 Facies Changes – Conceptual Model

[redacted]

[redacted]

[redacted]

2.5.5 Facies Changes – Uncertainties

BP's understanding of facies changes will be further supplemented with refined whole-core analysis from the Nonagon #1 appraisal well, and a range of geological scenarios will be conceptualized. Interpolation between known data points will be used for potential depositional environments based on the core description. In addition to the core description, the offset well logs, seismic data, and injectivity test results within the AoR will be incorporated to determine if the subsurface heterogeneity is being appropriately represented in alternate methods. Based on the current assessment, the following items are examples of key aspects that are being explored to ensure a full range of scenarios are being considered:

[redacted]

[redacted]

2.6 <u>Seismic History [40 CFR 146.82(a)(3)(v)]</u>

2.6.1 Seismic Activity and Collected Data

Based on reputable and extensive data from the Texas Seismological Network and Seismology Research (also known as TexNet) and the USGS, seismic activity is not expected to pose a threat to carbon dioxide containment at the Site. Seismic activity within the Gulf Coast Region is well researched, allowing for a confident description of natural seismicity risk surrounding the Site. The history of seismic activity in the region is documented beginning in the late 1800s (Reagor et al., 1988). Additionally, TexNet began operation in 2017 and is part of the Bureau of Economic Geology. TexNet consists of more than 150 seismic monitoring stations and can reliably record seismic events of less than one magnitude and greater across the state of Texas (Savvaidis et al., 2019). [redacted]

[redacted]

The USGS publishes national seismic hazard maps based on the determined estimations of location and sizes of future earthquakes (**Figure 2.26** (USGS Seismic Hazard Map)). The seismic hazard maps are used to inform seismic-design regulations for building and transportation infrastructure, government disaster management and mitigation strategies, and insurance rates. The available maps include more than 100 years of global earthquake observations, widely accepted seismology-based principles, and the best available data, methods, and models for seismic hazard assessment (Petersen et al., 2014).

Analysis of the most recent and real time data from TexNet supports the estimates identified in the 2014 USGS seismic hazard maps. [redacted]

[redacted]

2.6.2 Risk of Induced Seismic Activity

Existing CO_2 injection and sequestration projects which have limited their injection rates and pressures to below the calculated fracture pressure have been effective in limiting felt seismicity and/or microseismicity to below specified detection thresholds. Geomechanical analysis of the reservoir has value in determining what the risk of felt seismicity is as a result of the pressure perturbations caused by a given project and clarifies the mechanisms by which such risk can be reduced. To date, only one CO_2 injection project is known to have had microseismicity events attributed to CO_2 injection of sufficient magnitude to be felt (IEAGHG, 2022). The Cogdell Field in the Midland Basin of west Texas produces oil from the Canyon Reef limestone and uses CO_2 injection for enhanced oil recovery (EOR) operations. The CO_2 operations in the Cogdell Field have been associated with 18 M>3 events and a Mw 4.4 event in 2011, but no widespread public concerns have been reported.

[redacted]

[redacted]

[redacted]

2.7 Hydrologic and Hydrogeologic Information [40 CFR 146.82(a)(3)(vi), 146.82(a)(5)]

2.7.1 Major Hydrologic Units

From land surface downward, the Chicot aquifer, the Evangeline aquifer, the Burkeville confining unit, the Jasper aquifer, and the Catahoula confining system are the hydrogeologic units of the Gulf Coast aquifer system. In general, where the hydrogeologic units crop out, they do so parallel to the coast and thicken downdip to the southeast with the older units having a greater dip angle. [redacted]

[redacted]

2.7.1.1 Chicot Aquifer

The Chicot aquifer is the uppermost hydrogeologic unit in the Gulf Coast aquifer system and is contained in the geologic units from the land surface to the upper extent of the Evangeline aquifer. From oldest to youngest, the Chicot aquifer is contained in the Willis Sand, the Lissie

Formation (which includes the Bentley and Montgomery Formations), the Beaumont Formation, and the alluvium. The base of the Chicot aquifer is the Pliocene-age Willis Sand. The Willis Sand, which consists of Pliocene-age non-fossiliferous sand and sand beds with gravel, unconformably overlies the Goliad Sand and underlies the Lissie Formation. The origins of the sediment of this formation are similar to those of the Lissie and Beaumont Formations: namely, the accumulation of sediments through a cuesta and resulting deposition on a flat erosional plain. In the 15- to 20-mi-wide outcrop area, the Willis Sand is composed of stratified upward-fining gravelly coarse sand. The Willis Sand dips towards the coast at a rate between 10 and 25 ft/mi and ranges in thickness from about 100 ft in the outcrop area to 500 ft near the coastline.

The Pleistocene-age Lissie Formation contains thick beds of sand and interbedded fine-grained sediment that unconformably overlie the Willis Sand and are unconformably overlain by the Beaumont Formation. The Lissie Formation sediments are continental in origin and dip towards the coast at a rate of about 5 to 20 ft/mi. The Lissie Formation crops out in a belt about 30 miles (mi) wide parallel to the Texas coastline about 50 mi inland from the coast and is the most areally extensive outcrop in the Gulf Coast aquifer system. North of the Brazos River, the Lissie Formation has been mapped at the surface as the Montgomery and Bentley Formations. The Lissie Formation is composed of more than 60 percent sand in the updip area and between 20 and 60 percent sand in downdip area near the shore.

The updip extent of the outcrop area of geologic units that contain the Chicot aquifer follows the updip extent of the Lissie Formation in the eastern part of the area of interest. However, the updip extent of the geologic units that contain the Chicot aquifer transitions in the Trinity River area to that of the updip extent of the Willis Sand and follows this contact westward towards the Brazos River.

2.7.1.1.1 Vertical and Lateral Limits of the Chicot Aquifer

The updip limit of the Chicot aquifer is an undulating boundary approximately parallel to the coast and extending north. To the southeast, the freshwater part of the aquifer extends beneath the Gulf of Mexico. The altitude of the base of the Chicot aquifer ranges from more than 1,500 ft below Datum southeast of the coast to more than 420 ft above Datum in the outcrop area and varies locally because of numerous salt domes in the study area (Kasmarek, 2013).

The bottom of the Chicot was developed by Young and Draper (2020) by interpolating the picks of the base of the Willis at the locations of the geophysical logs. At each geophysical log, the location of the base of the Willis was selected to represent a transition from the sand-rich basal Chicot aquifer (Willis Formation) to the sand-poor top of the Evangeline. **Figure 2.29** shows the base of the Chicot aquifer as developed by Young and Draper (2020.

[redacted]

Young and Draper state that the dip angle of the Chicot aquifer is less than the dip angle of the Burkeville confining unit and as a result, the Evangeline aquifer becomes gradually thicker toward the coastline. Using the same study, the nearest well location located within the area of interest indicates the base of the Chicot aquifer to be at a depth of 1,799 ft below datum (**Table 2.4**).

[redacted]

2.7.1.1.2 Direction of Water Movement in the Chicot Aquifer

The estimated transmissivity of the Chicot aquifer ranges from 3,000 to 25,000 ft squared per day (ft2/d) based on aquifer test data (Ramage et al., 2022) whereas others quote a wider range of transmissivity of about 3,000 to about 50,000 (ft^2/d) (Kasmarek, 2013). The same study uses a storativity ranged from about 0.0004 to 0.1 (dimensionless).

For details on groundwater flow direction, refer to **Section 2.7.3** (Groundwater Flow) below.

2.7.1.2 Evangeline Aquifer

The Evangeline aquifer underlies the Chicot aquifer and is contained in the upper part of the Miocene-age Fleming Group and the predominantly Miocene-age Goliad Sand. The base of the Evangeline aquifer is within the middle Miocene part of the Fleming Group. The Fleming Group extends throughout the Gulf Coast aquifer system in Texas and eastern Louisiana and is composed of major fluvial deltaic depositional episode.

The Goliad Sand consists of about 80 percent sand, 10 percent clay, 5 percent gravel, and 5 percent calcium carbonate. The upper part of the Goliad Sand consists of finer grained sands that are cemented with calcium carbonate and contains thinner bedded sandstone than the lower part of the Goliad Sand.

The Goliad Sand crops out in a belt about 15 mi wide in Lavaca County. The Goliad Sand ranges in thickness from 200 ft at outcrop to about 1,400 ft near the coastline.

The Goliad Sand does not generally crop out at the surface in any large spatial extent other than in one area in Lavaca County. Rather, this unit pinches out into the overlying Willis Sand. Thus, rather than “outcrop” as a whole, the geologic units that contain the Evangeline aquifer are said to “subcrop”, or become truncated at the surface by geologically younger units (Ellis et al., 2023).

2.7.1.2.1 Vertical and Lateral Limits of the Evangeline Aquifer

The updip limit of the Evangeline aquifer is an undulating boundary approximately parallel to the coast and extending north. The altitude of the base of the Evangeline aquifer ranges from more than 5,300 ft below datum at the coast to 430 ft above datum in the outcrop area and varies locally because of numerous salt domes. The base of the Evangeline aquifer transgresses the stratigraphic boundary between the Goliad Sand and the Fleming Formation (Kasmarek, 2013).

For a description of the top and base of the Evangeline aquifer, refer to sections on the Chicot aquifer and Burkeville confining unit vertical and lateral limits, respectively.

2.7.1.2.2 Direction of Water Movement in the Evangeline Aquifer

The estimated transmissivity of the Evangeline aquifer ranges from 3,000 to 15,000 (ft^2/d) based on aquifer-test data whereas others quote a wider range of transmissivity of less than 5,000 ft2/d to more than 25,000 ft2/d (Kasmarek and Strom, 2002). The same study uses a storativity ranged from about 0.00005 to 0.1 (dimensionless).

For details on groundwater flow direction, refer to the **Section 2.7.3** (Groundwater Flow) below.

2.7.1.3 Burkeville Aquiclude

The updip limit of the Burkeville confining unit is an undulating boundary approximately parallel to the coast and extending north. The Burkeville confining unit lies stratigraphically below the Evangeline aquifer and above the Jasper aquifer and restricts flow between the Evangeline and Jasper aquifers because of its relatively large percentage of silt and clay compared to the percentages of the adjacent aquifers. In updip areas of the Burkeville confining unit, the sediments are slightly more transmissive and thus able to supply small quantities of water for domestic use. The altitude of the base of the Burkeville confining unit is coincident with the top of the Jasper aquifer and varies locally because of the numerous salt domes in the area (Kasmarek, 2013).

The Burkeville confining unit includes the middle part of the Miocene-age Fleming Group. The Fleming Group contains the Burkeville confining unit and the Evangeline aquifer towards updip areas; therefore, the description of the Fleming Group in the Evangeline aquifer section generally applies to the Burkeville confining unit. The Burkeville confining unit dips at a rate of about 65 to 80 ft/mi.

In most parts of the area of interest, the Burkeville confining unit is composed of many individual sand and clay layers; however, because of the large percentage of finer grained units compared to the Jasper aquifer and overlying Evangeline aquifer, the name “Burkeville confining unit” is appropriate because this unit impedes groundwater and is an effective barrier to the vertical flow of water. Compared to previous definitions of the Burkeville confining unit, the definition of this unit from Young and Draper (2020) includes a more regular thickening of the unit in the downdip direction and a downdip extent beyond the coastline (Ellis et al., 2023).

2.7.1.3.1 Vertical and Lateral Limits of the Burkeville Aquiclude

In the study by Young and Draper (2020), a top and bottom surface for the Burkeville Confining Surface was constructed starting at the outcrop and ending a few miles past the coastline. Strike sections were built following dip section construction using a similar workflow. The Burkeville confining unit was picked as a thick zone of clay-rich deposits within the upper part of the Fleming Group. A second step in constructing the Burkeville surfaces involved extracting points from the upper and lower surfaces along 28 transects to create a grid of closely spaced points that were then interpolated to create a continuous surface for the Burkeville confining unit.

Figures 2.30 and **2.31** show the top and the bottom surfaces of the Burkeville confining unit generated by interpolating the points from the dip cross-sections. **Figure 2.32** shows the thickness of the Burkeville confining unit generated as part of the study by Young and Draper (2020). The thickness of the Burkeville confining unit generally increases in the down-dip direction from the outcrop, where it is typically less than 150 ft, to offshore, where it exceeds 1,000 ft.

[redacted]

[redacted]

The highest clay fractions occur in the southwest in the vicinity of Wharton, Matagorda, and Jackson counties. In Galveston, the clay fraction is estimated to be between 0.7-0.8 (Young and Draper, 2020).

Besides clay fraction, another important attribute of the Burkeville confining unit is the total thickness of clay, shown in **Figure 2.32**, which also shows that in Galveston the thickness of the Burkeville confining unit is estimated to be between 401 to 929 ft (Young and Draper, 2020).

[redacted]

[redacted]

2.7.2 Minor Hydrologic Units

2.7.2.1 Catahoula Sandstone

The basal unit of the Gulf Coast aquifer system is the Catahoula confining system, which comprises the Catahoula Sandstone and, downdip, the Anahuac and Frio Formations. The Jasper aquifer is underlain by the Catahoula confining system, which is composed mostly of clay or tuff. The Catahoula confining system impedes substantial exchange of water between the Jasper aquifer and underlying units (Kasmarek, 2013).

2.7.3 Groundwater Flow

2.7.3.1 Regional Groundwater Flow

Recharge groundwater enters the system in topographically high updip outcrops of the hydrogeologic units in the northwestern parts. Groundwater then flows relatively short distances, discharging into topographically lower areas to features such as streams, or flows longer distances southeastward through deeper zones, where it is discharged by diffuse-upward leakage in topographically low areas along coastal areas.

An appreciable amount of the precipitation that infiltrates the subsurface (total recharge) in the relatively topographically high outcrop areas of the hydrogeologic units joins local flow systems. Thus, much of the total precipitation enters from and exits to the shallow subsurface by streams and in topographically low areas. A proportionally smaller amount of the total recharge joins intermediate flow systems, and an even smaller amount of the total recharge joins regional flow systems.

The natural groundwater-flow system has been altered in places (the Houston area, for example) by decades of substantial and concentrated withdrawals from the Chicot and Evangeline aquifers. By 1977, water levels had declined to as much as 250 ft and 350 ft below datum in the Chicot and Evangeline aquifers, respectively. Because the Chicot and Evangeline aquifers are hydraulically connected, in these areas, withdrawals have increased vertical head gradients and have induced downward flow from local and intermediate flow systems into the regional flow system, thus capturing some flow that would have discharged naturally (Kasmarek, 2013).

The Burkeville confining unit lies stratigraphically below the Evangeline aquifer. This unit is considered a no-flow basal unit in the Houston area that restricts the upward movement of more dense saline water from depth (Kasmarek and Strom, 2002).

Near the coast and at depth, saline water is present. The saline water causes less-dense freshwater that has not been captured and discharged by wells to be redirected upward as diffuse leakage to shallow zones of the aquifer system and ultimately to be discharged to coastal water bodies (Kasmarek and Robinson, 2004).

2.7.3.2 Local Groundwater Flow

Using hydrochemical data from the TWDB[33] and an ionic balance of +/- 2%, data was plotted according to county in **Figure 2.33**. Series 1 datasets are sampled from Galveston County, whilst Series 2 are datasets that are sampled from wells in Harris County. Series 1 show both $NaHCO_3$ and NaCl type groundwater, while Series 2 show greater prevalence of HCO_3^- type water.

[redacted]

[33] https://www3.twdb.texas.gov/apps/reports/GWDB/WaterQualityByAquifer

The same observations have been made by Kreitler et al., 1977:

> The freshwater lens extends to depths of 3,000 ft in Harris County, whereas in Galveston County the base of freshwater is only 1,000 ft. [This is shown on **Figure 2.34** below, which depicts a cross-section though eastern Liberty, Harris, and Galveston Counties.] The fresh groundwater in the two counties is composed of different hydrochemical facies. Harris County waters are Na-Ca-HCO_3-Cl or Na-HCO_3-Cl waters, whereas Galveston County waters are Na-Cl-HCO_3 waters (hydrochemical facies classification from Back, 1966).
>
> Groundwater in Harris County appears to be recharged in the northern part of the county (as well as in the counties north of Harris) and discharged in southern Harris County….

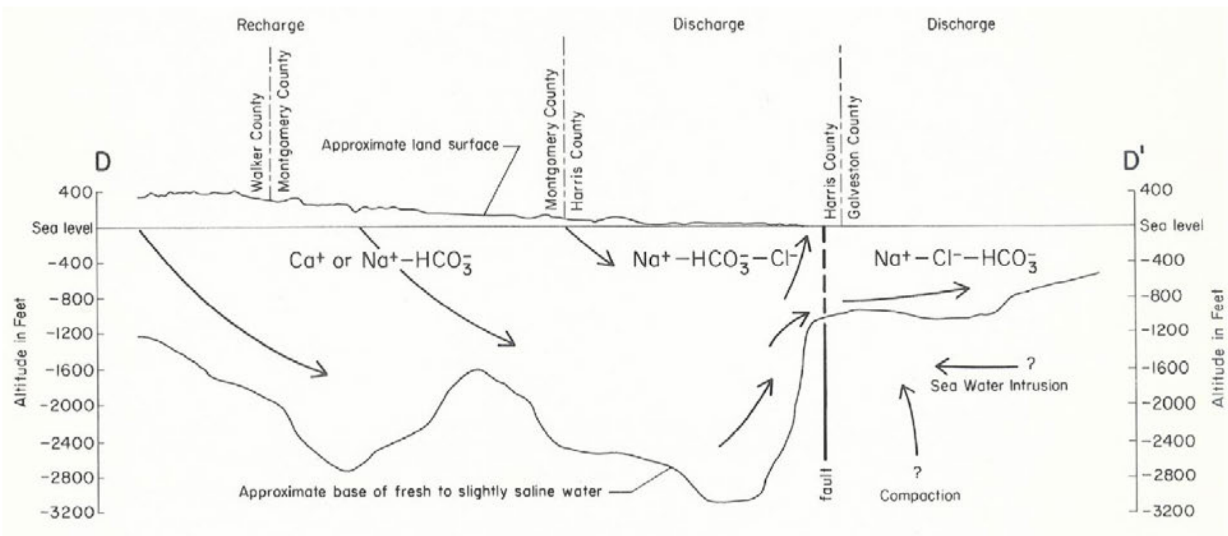

Figure 2.34. Cross-Section Showing Hydrochemical Facies of Aquifer and Depth to Base of Freshwater (Kreitler et al., 1977)

> In Galveston County, analysis of water chemistry indicates a mixing of meteoric water from Harris County and saline water. In comparison to Harris County waters, Na^+ and Cl^- concentrations in Galveston County increase substantially, whereas Ca^{2+} and HCO_3^- concentrations increase slightly. Na/Cl ratios are increasing at 0.95:1 mole ratio but no correlation exists between concentrations of Na^+ and HCO_3^-.
>
> Either sea water or formation water is mixing with meteoric water in Galveston to form the Na-Cl-HCO_3 water. Assuming communication of seawater with the aquifer through high-percent-sand trends in Galveston County, a freshwater lens overlying intruding sea water could develop. The elevation of the potentiometric surface in Galveston County was approximately 25 to 30 ft above sea level before ground-water development. …the

fresh-water lens would be 1,000 to 1,200 ft thick, which is the approximate thickness of the fresh-water lens in Galveston County.

Alternatively, Jones (1968) suggests that the Gulf coastal plain may be a discharge zone for formation water migrating up-dip from deeper compacting sediments. Water from the saline Miocene Fleming Formation, which underlies the fresh-water aquifer, is typically high in Na^+, Cl^-, HCO_3^-, and Ca^{2+}. Elevations of the potentiometric surface of deep wells (3,000 to 7,000 ft) in Galveston County were 10 to 60 ft (1930s to 1940s) below land surface; thus, formation waters have the hydraulic potential to migrate toward the fresh-water lens. Either source could cause the observed chemical alteration of the Galveston County fresh-water lens.

The structural framework of the aquifer, in part, controls the regional hydrology of Harris and Galveston Counties. A major fault zone between Harris and Galveston Counties separates the different water types to each county. Dip-oriented cross-sections show appreciable vertical displacements and abrupt thickening of the Lissie Formation (Alta Loma sand). Displacements increase to as much as 200 ft at a depth of 1,000 ft.

This fault zone acts as a partial hydrologic barrier that separates two partly independent flow systems – groundwater flow in Harris County and groundwater flow in Galveston County. The abrupt change in elevation of the base of freshwater is coincident with the faulting. Below 1,000 ft, meteoric groundwater apparently is not flowing across the boundary but is discharging into shallower aquifers in southern Harris County, and probably causing the high Na^+/Ca^{2+} ratios observed in these waters. Above 1,000 ft, some meteoric water is flowing across the fault from Harris County into Galveston County as evidenced by the low dissolved solids of the water in Galveston. Original elevation of the piezometric surface and sodium bicarbonate concentrations indicate no surface recharge of meteoric water in Galveston County.

The fault has greatly reduced the flow and permitted the base of the fresh-water lens in Galveston County to rise to 1,000 ft. The fresh-water/saline-water interface represents an equilibrium between the energy potential of the meteoric waters and the energy potential of the saline waters. If the hydraulic gradient of the meteoric water lens increases, then the interface becomes deeper (as in Harris County); reducing the hydraulic gradient of the meteoric water will cause the interface to rise. This interface, therefore, represents a dynamic equilibrium.

Shallow Gulf Coast saline water was previously considered to be connate water that is being flushed by fresh meteoric water. Because of Pleistocene changes in sea level this concept is not feasible. Sea level reached a low stand of approximately 300 ft below present sea level about 18,000 years ago. Shoreline was as much as 120 miles gulfward from its present position, and the San Jacinto-Trinity Rivers eroded deeply in the vicinity of Galveston Bay. Much of the continental shelf was subaerially exposed. The base level of the coastal hydrologic system during Pleistocene low stand was a few hundred feet below its present elevation. The hydrologic regime of the coastal aquifers must have been greatly altered. Present day discharge zones in Harris and Galveston Counties would have been recharge zones 18,000 years ago. The superposed, high percent-sand trends of

> Harris, Galveston, and Brazoria Counties would have been areas for optimum recharge. At that time, meteoric waters would have flushed any saline water from the coastal aquifers. At low stand of sea level, fresh groundwater probably circulated deep beneath Galveston County.
>
> The hydrologic regime has changed with the rise in sea level. The stacked sand systems, which were recharge zones during low stand of the sea may now be discharge zones. The hydraulic gradient of the meteoric groundwater in Galveston County has been greatly reduced, and a new dynamic equilibrium has been reached between freshwater and salt water. Brackish to saline waters in the coastal aquifers are either sea water or deep formation water that has recently intruded but are not residual waters of deposition that have yet to be flushed from the sediments.

Kreitler concludes that Pleistocene sea-level changes and growth faults are the controlling parameters of the hydrochemical facies and over shadow any control from sediment distribution in Harris and Galveston counties (Kreitler et al., 1977).

2.7.4 Aquifers Serving as Potential Sources of Drinking Water

As summarized by Ellis et al (2023), since the early 1900s, most of the groundwater withdrawals in the study area have been from three of the hydrogeologic units that compose the Gulf Coast aquifer system – the Chicot, Evangeline, and Jasper aquifers, and, more recently, from the Catahoula confining unit. Withdrawals from these units are used for municipal supply, commercial and industrial use, and irrigation purposes. Withdrawals of large quantities of groundwater in the greater Houston area have caused widespread groundwater-level declines (where "groundwater level" is synonymous with "groundwater head") in the Chicot, Evangeline, and Jasper aquifers of more than 300 ft.

Early development of the aquifer system, which began before 1900, resulted in nearly 50 percent of the eventual historical groundwater-level minimums having been reached as early as 1946 in some parts of the greater Houston area. The greatest sustained annual groundwater-level declines during the study period occurred in the historical Houston area and Pasadena area during 1937–1952, averaging 10–14 ft/yr, compared to the declines of about 8 ft/yr during 1962–1972, generally the second greatest period of sustained annual declines.

Groundwater-level data from co-located wells indicate: (1) minimal groundwater-level changes over time in the shallowest wells that generally are climate and recharge driven, and (2) a transition zone between about 100 and 250 ft below land surface, below which groundwater is generally under confined conditions and groundwater levels are primarily affected by groundwater withdrawals. A substantial degree of similarity is observed in the groundwater-level patterns from co-located wells at the borehole extensometer sites which are under confined conditions.

Substantial groundwater-level declines have caused more than 9 ft of land-surface subsidence from depressurization and compaction principally of fine-grained sediments interbedded in the aquifer system. Subsidence prior to 1978 was generally concentrated in central, south-central, and southeastern Harris County and in Galveston County. More recent subsidence has occurred in northern, northwestern, and western Harris County, in Montgomery County, and in northern Fort Bend County. Subsidence in the greater Houston area has generally occurred on a broad scale, although substantial subsidence gradients across relatively short distances occurred in the Baytown and Texas City areas. Observed rates of subsidence generally correspond to the rates of groundwater-level declines, and absent a sustained groundwater-level recovery, compaction has continued to occur in some areas as pore pressures (equivalent hydraulic heads) in the fine-grained units slowly equilibrate with groundwater levels in the surrounding higher permeability coarse-grained aquifer material.

The adverse effects of groundwater withdrawals led to the 1975 establishment of the Harris-Galveston Coastal Subsidence District (after 2005, the Harris-Galveston Subsidence District [HGSD], used hereinafter) to provide groundwater management and regulation. An additional subsidence district, the Fort Bend Subsidence District (FBSD), was established in 1989, along with 13 groundwater conservation districts between 2001 and 2014 (Ellis et al., 2023).

Since then, groundwater levels have generally risen in Brazoria, Fort Bend, Galveston, and Liberty Counties and throughout most of the southwestern, central, south-central, southeastern, and eastern parts of Harris County (Ellis et al., 2023).

Table 2.6 (Water Wells within the AoR) lists the identified water wells within the AoR and **Figure 2.35** (Location of Water Wells within the AoR) shows their location within the AoR. No springs were identified as discussed in **Section 2.2.1.3** (Project Area Map – Springs).

[redacted]

[redacted]

2.8 Geochemistry [40 CFR 146.82(a)(6)]

The PR cubic EoS is used in all coupled flow and geochemical simulations and standalone geochemical models. The main function of the EoS is to appropriately model the non-ideal behavior of CO_2 in the supercritical state. Although providing a more simplistic treatment, cubic EoS provide for a common platform across tools, can account for liquids in the system, and are less specific than some forms that only deal with gaseous properties and/or pure gas mixtures.

The EoS calculates the fugacity of CO_2 in the gas/dense phase in combination with Henry's Law that is used to calculate fugacity in the aqueous phase. This facilitates solubility calculations of CO_2 in aqueous solutions under non-ideal, non-isothermal conditions.

Example PR EoS formulation:

$p = RT/Vm - b - aA/V 2 + 2bV - b2$

Where:

p - pressure (absolute)
Vm - molar volume (1 mole of gas or liquid)
R - ideal gas constant (8.3144621 Joule per mole kelvin)
T - absolute temperature (kelvin)
Tc - critical temperature
pc - critical pressure
$Tr= T/Tc$
$A= (1 + k(1-Tr0.5))2$
$b = 0.07780RTc/pc$
$a = 0.45724 R2 Tc2/pc$
$k = 0.37464 + 1.54226w - 0.26992w2$

[redacted]

[redacted]

2.8.1 Groundwater Monitoring

[redacted] To date, BP has not drilled any shallow wells for the collection of USDW data; therefore, publicly available and accessible data obtained from the TWDB was searched to understand the geochemical baseline of the local Chicot aquifer prior to any CO_2 injection activity.

Within the AoR, there is a lack of reported, high-quality groundwater geochemistry data which can be utilized to undertake a thorough assessment. [redacted] Historically, data classed as “charge unbalanced” are recorded as such due to a lack of full major/minor ion chemistry/reported laboratory errors when calculating, in some cases, the charge balance is not recorded for samples collected prior to 1990. Three samples contain pH data, all contain TDS, but none report metal concentrations. Consistent pressure data was not reported in the early well reports, nor were sample and preservation methods, analytical methods, or QA/QC used (other than standard charge balance). No data exists past 1969, with the earliest samples being reported in 1939. Due to the lack of data, all data with any major/minor ions reported has been included in **Table 2.8** for two reasons: 1) To highlight the lack of suitable data available for this study, and 2) if we were to filter data based on BP best practice, there would be nothing to report.

[redacted]

[redacted]

[redacted]

All data obtained for the five TWDB wells in **Table 2.7** are plotted on a piper plot (**Figure 2.36**). Piper plots are a useful visual tool for understanding the relative abundance of ions within a given fluid sample. [redacted]

[redacted]

Fluid data obtained from the Fleming Group confining and injection zones are presented in **Table 2.9**, alongside known detection limits and MCL/public health goal limits. Due to the lack of good-quality, accessible groundwater data from local landowner and industrial wells in the West Bay area, the impact of any migration of undiluted brine into the USDW is not able to be assessed at this time. Ideally, the modal value of local groundwater data would be compared to the Fleming Group brine data in order to establish what ions would be detectable above baseline. Instead, we have only been able to compare Fleming Group brines to published health guidelines for major/minor ion concentrations within groundwater; however, this does not represent the true risk if unintended migration where to occur. Even if Fleming Group brines show values above public health goals, without adequate modal and data ranges from a representative number of groundwater wells, it remains unknown whether these ions could be detected above baseline concentrations.

[redacted]

[redacted]

[redacted]

2.8.1.1 Groundwater Well Data to Be Collected/Analyzed from New Monitoring Wells

Samples will be collected with an appropriate method to provide for representative analysis as described in the Testing and Monitoring Plan (**Appendix E**). Laboratory results will be tabulated, including duplicates and blanks, for QA purposes and a narrative interpreting the results will be prepared.

2.8.2 Geochemical Modeling

BP also performed geochemical modeling to determine the geochemical effects upon CO_2 containment and near well-bore processes (salt-drop out). The full discussion, results, and conclusions can be found in the Geochemical Modeling and Simulation Results in **Attachment 1**. Geochemical simulations are conducted at a range of scales, and the tools are selected based on conceptual model considerations. [redacted]

Prior to undertaking the simulation work, conceptual models were created to aid in designing test case scenarios. **Figure 2.37** shows three of these conceptual models, based upon assumption of both free-phase and CO_2 saturated brine plume migration, both spatially and vertically. [redacted]

[redacted]

The combination of conceptual models, equilibrium-based geochemical simulations (including reaction path models), mineralogical and petrographic data provided for a thorough assessment of fluid-fluid and fluid-rock interactions. [redacted]

[redacted]

2.8.2.1 PHREEQC and GWB Equilibrium-Speciation-Saturation Modeling

[redacted]

2.8.2.2 Mineral Compositional Data

BP used detailed petrography and quantitative X-ray diffraction obtained from the appraisal well to determine the mineral composition of the injection and confining zones. [redacted] **Table 2.10** shows the XRD analysis for plug samples recovered from the appraisal well, including both zones. [redacted]

[redacted]

Textural relationships are defined with a combination of core descriptions, petrography and SEM. [redacted] A more detailed explanation of the petrographic analysis is presented in **Sections 2.4.1.1 and 2.4.2.1** (Minerology and Petrology of the Injection Zone and Confining Zone, respectively). Clay typing and bulk elemental and mineral compositions are defined using electron microprobe and XRD analysis. Clay morphology, the habits of mineral overgrowths and the nature of pore-filling cements are key factors in understanding the impacts of reactive fluids on the rock mass.

[redacted]

[redacted]

[redacted]

2.8.2.3 Geochemical Model Narrative Interpretation

The integrated conceptual modelling and multi-level simulation approach adopted provides an effective method for understanding the impacts of CO_2 injection on both injection and confining zone units. [redacted]

[redacted]

[redacted]

2.8.3 CO_2 Stream Compatibility

Prior to undertaking geochemical simulation work, conceptual models were created by BP to aid in designing test case scenarios for geochemical modeling. [redacted]

[redacted] The resulting low vertical intrinsic permeability, imparted by flat-lying and gently dipping stratal surfaces and bedding planes, limits vertical migration of low-density fluids and preferentially directs flow horizontally. This is partly a consequence of maintaining CO_2 in dense phase that reduces the buoyancy pressure by a factor of up to four compared with gaseous CO_2. The intrinsic permeability in the vertical plane influences the relative permeability drainage cycles by limiting water saturation, which, therefore, reduces the CO_2 mobility. These aspects of reservoir physics control the fluid-rock contact relationships and the potential for fluid-rock reactivity.

There are both physical and chemical interactions between free-phase CO_2 and the injection zone media. The potential for each is controlled by the H_2O saturation state of the CO_2. The intention is to inject dehydrated CO_2 to minimize infrastructure corrosion, which results in brine desiccation at the injection sand face and the near well region of the injection zone. If dehydrated CO_2 were to contact clay rich sediments, the bound water in the clays would vaporize causing mineral desiccation and shrinkage. The solubility of H_2O in CO_2 is an approximate order of magnitude lower than the solubility of CO_2 into brine where the saturation limit is reached rapidly. [redacted]

[redacted] Most framework siliciclastic minerals (e.g., quartz and feldspars) are resistant to low acidity brines. Phylosilicates (clays and micas) show variable reactivity, which is commonly limited in low permeability zones due to low fluid velocities. Isolated accumulations in sandstone lithologies are more susceptible to dissolution and some (e.g., chlorite) readily dissolve. The reactive behavior and concomitant changes in mineral composition and structure at the interface between the injection and confining zones commonly limits the vertical movement of CO_2 in siliciclastic depositional systems (e.g., clay swelling and incongruent dissolution of feldspars to clays that occludes pore space by increasing matrix volume).

[redacted] Thus, BP concludes that the anticipated CO_2 stream should be compatible with the injection and confining zone properties.

2.8.4 Experimental Modeling

[redacted]

[redacted]

2.8.4.1 Experimental Solids

Material for the experimental program will be gathered from whole core samples defined by rock typing analysis. [redacted]

2.8.4.2 Experimental Impurities

[redacted]

2.8.4.3 Experimental Rock Sample

Porosity and permeability were obtained from routine core analysis conducted on whole core and rotary sidewall core samples. [redacted]

2.8.4.4 Geochemical Reaction

Experimental results will be provided.

2.9 Identifying the Risk of Contaminant Mobilization

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

2.10 Site Suitability [40 CFR 146.83]

BP has thoroughly analyzed the geology, hydrogeology, geochemistry, and subsurface characteristics at and in the vicinity of the Site. Through the drilling and development of appraisal well Nonagon #1, and analysis of associated data, BP has demonstrated, throughout this Application that the geologic systems present at the Site consist of appropriate and protective injection and confining zones.

In particular, the site-specific data from the appraisal well, as well as BP's additional research, field work, and modeling have confirmed that:

[redacted]

[redacted]

Based upon the foregoing, the Site meets the suitability requirements set forth at 40 CFR 146.83.

2.11 References for Site Characterization

[redacted]

[redacted]

[redacted]

2.12 Other Information (Including Surface Air and/or Soil Gas Data, if Applicable)

BP plans to work with the University of Texas at Austin Bureau of Economic Geology's Gulf Coast Carbon Center to assess the need for and utility of surface air and/or soil gas monitoring at the Site.

3 AOR AND CORRECTIVE ACTION [40 CFR 146.84]

BP has prepared the AoR and Corrective Action Plan (**Appendix B)** in accordance with 40 CFR 146.82(a)(13) and 146.84(b). Detailed documentation regarding the computational modeling [40 CFR 146.84(c)] is submitted to the Geologic Sequestration Data Tool (GSDT) AoR and Corrective Action Module. This includes:

- Model Domain
- Processes Modeled
- Rock Properties
- Boundary Conditions
- Initial Conditions
- Operational Information
- Model Output, and
- AoR Pressure Front Delineation.

The AoR and Corrective Action Plan provide a summary of the results of the modeling and AoR. Wells identified for corrective action are detailed within this plan.

The AoR and Corrective Action can be found in **Appendix B**.

AoR and Corrective Action GSDT Submissions
GSDT Module: AoR and Corrective Action ***Tab(s):*** All applicable tabs Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☒ Tabulation of all wells within AoR that penetrate confining zone ***[40 CFR 146.82(a)(4)]*** ☒ AoR and Corrective Action Plan ***[40 CFR 146.82(a)(13) and 146.84(b)]*** ☒ Computational modeling details ***[40 CFR 146.84(c)]***

4 FINANCIAL RESPONSIBILITY [40 CFR 146.85]

The financial responsibility demonstration can be found in **Appendix C** and includes a description of the potential financial mechanisms and cost estimates that will be used for costs associated with corrective action, injection well plugging, post-injection site care and site closure, and emergency and remedial response for the Site, as required by 40 CFR 146.82(a)(14) and 40 CFR 146.85.

Financial Responsibility GSDT Submissions
GSDT Module: Financial Responsibility Demonstration ***Tab(s):*** Cost Estimate tab and all applicable financial instrument tabs Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☒ Demonstration of financial responsibility ***[40 CFR 146.82(a)(14) and 146.85]***

5 INJECTION WELL CONSTRUCTION [40 CFR 146.86]

Construction of the injection wells will meet the requirements of 40 CFR 146.82(a)(12) and 40 CFR 146.86. The procedures and specifications [redacted] are described in **Appendix J -** Injection Well Construction as required in 40 CFR 146.86(a).

Each injection well has the following documentation and details provided:

- Injection well operating conditions (**Appendix A** – Summary of Requirements);
- Injection well construction details including open hole diameters and intervals, casing specifications, tubing specifications, packer specification, and construction diagrams (**Appendix J** – Injection Well Construction); and
- Proposed Stimulation Program (40 CFR 146.82(a)(9)) (**Appendix I** – Stimulation Program).

5.1 Proposed Stimulation Program [40 CFR 146.82(a)(9)]

BP is proposing a possible stimulation program for the injection wells to provide reliable sand control over the life of injection. At least 30 days prior to implementing a stimulation program, BP will provide notice of proposed stimulation activities and proposed stimulation procedures to the UIC Program Director in writing, per 40 CFR 146.91(d)(2). The notice will describe fluids to be utilized for stimulation activities and demonstrate that the stimulation is not expected to interfere with containment. Details of the proposed stimulation program are provided in **Appendix I**.

5.2 Construction Procedures [40 CFR 146.82(a)(12)]

The construction of [redacted] will be performed following industry best practices. Materials used in the construction of the wells will conform to American Petroleum Institute (API) and National Association of Corrosion Engineers (NACE) standards. Injection well construction details can be found in **Appendix J**.

To appropriately drill the wells and protect USDWs, construction will follow the guidelines outlined in the Pre-Operational Testing Program (**Appendix D**), which includes details on the following:

- Deviation Checks [40 CFR 146.87(a)(1)];
- Tests and Logs During Drilling [40 CFR 146.87(a)];
- Tests and Logs Before, During, and After Casing Installation [40 CFR 146.87(a)(2)-(3)]; and
- Demonstration of Mechanical Integrity [40 CFR 146.87(a)(4)].

5.3 Injection Well Details

[redacted] The depth intervals will be based on site-specific geology, with the general diameters, casing, tubing, and packer specifications as detailed in **Appendix J**. BP will provide the UIC Program Director with supplemented Construction Details for each injection well in a final injection well construction plan prior to each well's installation.

6 PRE-OPERATIONAL LOGGING AND TESTING [40 CFR 146.87]

The Pre-Operational Logging and Testing Plan in accordance with 40 CFR 146.82(a)(8) and 146.87 is designed to gather confining layer and injection zone data to confirm BP's understanding of subsurface conditions, in addition to providing initial conditions data to understand pre-injection site conditions.

The Pre-Operational Testing Program can be found in **Appendix D**.

Pre-Operational Logging and Testing GSDT Submissions
GSDT Module: Pre-Operational Testing ***Tab(s):*** Welcome tab Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☒ Proposed pre-operational testing program ***[40 CFR 146.82(a)(8) and 146.87]***

7 WELL OPERATION [40 CFR 146.82(A)(7) AND (10) AND 40 CFR 146.88]

The following operational procedures and operating conditions are proposed to meet the requirements of 40 CFR 146.82(a)(7) and (10) and ensure compliance with the requirements in 40 CFR 146.88 for operation of the injection wells.

7.1 Operational Procedures [40 CFR 146.82(a)(7) and (10)]

The operating conditions proposed are based on the average steady-state condition for operation of the injection wells. Actual operating conditions may vary due to throughputs and routine plant maintenance outages. Further information on the proposed operational conditions can be found in the AoR and Corrective Action Plan (**Appendix B**).

BP will gather pre-operational data prior to injection in accordance with 40 CFR 146.82(a)(8), as described in the Pre-Operational Testing Plan (**Appendix D)**. Parameters described in these plans may change based on the logging and testing data.

7.2 Proposed CO_2 Stream [40 CFR 146.82(a)(7)(iii) and (iv)]

7.2.1 Carbon Dioxide Stream Analysis

The CO_2 stream delivered to the injection wells will be derived from [redacted] The corrosive nature of CO_2 and the influence of impurities have been assessed through a review of the established literature, dedicated laboratory experimentation, and computational modelling performed both internally and collaboratively via participation in joint industry programs.

[redacted] Other trace impurities will be treated to levels required by the corrosion monitoring plan. Generally, this treatment will occur [redacted]

[redacted] Specification limits for impurities are driven by requirements of the transportation pipeline, which are generally more stringent than injection well requirements due to material selection (i.e., pipeline metallurgy). Therefore, the composition of the injected fluid presents no significant concerns regarding its interactions with subsurface fluids or suitability of the well materials.

BP will analyze the CO_2 stream during the operation period to yield data representative of its chemical and physical characteristics and to meet the requirements of 40 CFR 146.90(a). Sampling will take place both on a continuous and intermittent basis via online gas analysis and routine spot sampling, respectively. Analysis of the CO_2 stream will be monitored closely to assess risks to flow assurance and mechanical integrity of both the CO_2 pipeline and the injection well, as well as any impact on fluid behavior in the subsurface. Sample points will be located at the receipt point(s) of CO_2 stream(s) into the pipeline network to assess the quality of the CO_2 stream prior to transportation and injection. Sampling will occur at the frequencies described in **Appendix E** and is subject to further assessment and approval from the UIC Program Director.

BP will analyze the CO_2 for specific constituents utilizing detailed analytical methods as described in **Table 2** (Summary of Analytical Parameters for CO_2 Stream) in the Testing and Monitoring Plan (**Appendix E**). The specific analytical methods employed and frequency of sampling will vary based on criticality to operations and the analyzers used for continuous monitoring.

The volume of CO_2 injected will be calculated from the mass flow rate obtained from the mass flow meter installed on the injection line. Flow rate is measured on a mass basis (kilograms/hour). The downhole pressure and temperature data will be used to perform the injectate density calculation.

7.2.2 Carbon Dioxide Stream in the AoR Model [40 CFR 146.82(a)(7)(i) and (ii)]

[redacted]

[redacted] This allows the salinity (among the other aqueous properties) to adjust during and after injection.

Table 7.1 provides the proposed operational parameters and conditions of the injection wells in accordance with 40 CFR 146.82(a)(7)(i)-(ii). The average annual injection rate is the rate of injection used for AoR modeling and represents the maximum injection volume for any given year. The maximum instantaneous injection rate will be utilized in the event of well maintenance to preserve the average annual injection rate. It will honor the maximum injection pressure for safe operating conditions, as well as any other surface conditions.

[redacted]

7.3 Stimulation Plan

BP is proposing a possible stimulation program for the injection wells to provide reliable sand control over the life of injection. At least 30 days prior to implementing a stimulation program, BP will provide notice of proposed stimulation activities and proposed stimulation procedures to the UIC Program Director in writing, per 40 CFR 146.91(d)(2). The notice will describe fluids to be utilized for stimulation activities and demonstrate that the stimulation is not expected to interfere with containment. Details of the proposed stimulation program are provided in **Appendix I**.

8 TESTING AND MONITORING [40 CFR 146.90]

The Testing and Monitoring Plan was developed in accordance with 40 CFR 146.82(a)(15) and 146.90 and is provided in **Appendix E**. Testing and monitoring in accordance with this plan will demonstrate that the Site is operating as anticipated, that the sequestered CO_2 plume and pressure front are moving as predicted, and that the CO_2 plume does not endanger any USDWs.

The Testing and Monitoring Plan will be reviewed at a minimum of every five years and will be adjusted to reflect any changes to the Site conditions over time. The amended plan will be sent to the UIC Program Director for approval in accordance with 40 CFR 146.90.

Testing and Monitoring GSDT Submissions
GSDT Module: Project Plan Submissions ***Tab(s):*** Testing and Monitoring tab Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☒ Testing and Monitoring Plan ***[40 CFR 146.82(a)(15) and 146.90]***

9 INJECTION WELL PLUGGING [40 CFR 146.92]

The Injection Well Plugging Plan was developed in accordance with 40 CFR 146.82(a)(16) and 40 CFR 146.92(b) and is provided in **Appendix F**. Prior to injection well plugging, the mechanical integrity of each well will be tested to confirm no pathways have been established between the injection zone and USDWs or ground surface. Well logs will also be completed and compared to the pre-injection and operational phases. Prior to the injection well plugging operations, all tubing and packers will be removed.

Injection Well Plugging GSDT Submissions
GSDT Module: Project Plan Submissions ***Tab(s):*** Injection Well Plugging tab Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☒ Injection Well Plugging Plan ***[40 CFR 146.82(a)(16) and 146.92(b)]***

10 POST-INJECTION SITE CARE (PISC) AND SITE CLOSURE [40 CFR 146.93]

The PISC and Site Closure Plan was developed in accordance with 40 CFR 146.82(a)(17) and 146.93(a) and is provided as **Appendix G**. The plan describes activities for monitoring groundwater quality and tracking the position of the CO_2 plume and pressure front following termination of the injection operations. Post-injection monitoring will continue for at least 50 years or until BP's demonstration of non-endangerment of USDWs has been approved by the UIC Program Director pursuant to 40 CFR 146.93(b)(3). Following the approval for site closure, BP will plug all monitoring wells, restore the Site to its initial condition, and submit a site closure report and associated documentation.

BP has not requested an alternative PISC timeframe in this application. Pursuant to 40 CFR 146.93(c)(1), BP may request, and the UIC Program Director may approve, an alternative PISC timeframe if appropriate in the future.

PISC and Site Closure GSDT Submissions
GSDT Module: Project Plan Submissions ***Tab(s):*** PISC and Site Closure tab Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☒ PISC and Site Closure Plan ***[40 CFR 146.82(a)(17) and 146.93(a)]***
GSDT Module: Alternative PISC Timeframe Demonstration ***Tab(s):*** All tabs (only if an alternative PISC timeframe is requested) Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☐ Alternative PISC timeframe demonstration ***[40 CFR 146.82(a)(18) and 146.93(c)]***

11 EMERGENCY AND REMEDIAL RESPONSE [40 CFR 146.94]

The Emergency and Remedial Response Plan (ERRP) is designed to meet the requirements of 40 CFR 146.82(a)(19) and 146.94(a) and is provided as **Appendix H**. BP has outlined in this application steps to prevent impacts to USDWs, the environment, and human health. The ERRP details actions to be taken if an emergency event occurs at the Site. Furthermore, the ERRP demonstrates the process and response to emergencies to ensure protection of USDWs, health and safety, and the surrounding environment.

Emergency and Remedial Response GSDT Submissions
GSDT Module: Project Plan Submissions ***Tab(s):*** Emergency and Remedial Response tab Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☒ Emergency and Remedial Response Plan ***[40 CFR 146.82(a)(19) and 146.94(a)]***

12 INJECTION DEPTH WAIVER AND AQUIFER EXEMPTION EXPANSION [40 CFR 146.82(D) AND 146.95(A)] AND [40 CFR 146.4(D) AND 144.7(D)]

No Injection Depth Waiver or Aquifer Exemption Expansion is being requested by BP at this time.

Injection Depth Waiver and Aquifer Exemption Expansion GSDT Submissions
GSDT Module: Injection Depth Waivers and Aquifer Exemption Expansions ***Tab(s):*** All applicable tabs Please use the checkbox(es) to verify the following information was submitted to the GSDT: ☐ Injection Depth Waiver supplemental report ***[40 CFR 146.82(d) and 146.95(a)]*** ☐ Aquifer exemption expansion request and data ***[40 CFR 146.4(d) and 144.7(d)]***

13 OPTIONAL ADDITIONAL PROJECT INFORMATION [40 CFR 144.4]

Various Federal laws may apply to the issuance of a Class VI permit. If applicable, BP will follow the procedures of relevant laws, including those listed below. For the items below, please see **Table 1.1** for a full list of potential applicable environmental permits and requirements for the Site.

13.1 Wild and Scenic Rivers Act

The Wild and Scenic Rivers Act, 16 U.S.C. 1273 et seq. states that "certain selected rivers which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations."

In accordance with the Wild and Scenic Rivers Act, the presence of national wild and scenic rivers will be determined within the areas that may be impacted by activities associated with the Site. Based on the location of the Site, the Wild and Scenic River Act is not applicable.

13.2 National Historic Preservation Act

The National Historic Preservation Act of 1966, 16 U.S.C. 470, et seq. states that "it shall be policy … to use measures, including financial and technical assistance, to foster conditions under which our modern society and our prehistoric and historic resources can exist in productive harmony and fulfil the social, economic, and other requirements of present and future generations."

In accordance with the National Historic Preservation Act, the presence of properties listed or eligible for listing in the National Register of Historic Places will be determined within the areas that may be impacted by activities associated with the Site. In the event a historic property is identified, additional procedures and policies may be implemented, including historic and/or cultural resource surveys.

13.3 Endangered Species Act

The Endangered Species Act, 16 U.S.C. 1451 et seq. states that "the purposes … are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as my be appropriate to achieve the purposes of the treaties and conventions set forth…"

In accordance with the Endangered Species Act, the presence of endangered or threatened species will be determined within the areas that may be impacted by activities associated with the Site. In the event an endangered or threatened species is identified, additional procedures and policies may be implemented, including endangered or threatened species surveys and/or biological assessments. If required, proper permits and authorizations will be acquired prior to construction and operation of the Site.

13.4 Coastal Zone Management Act

The Coastal Zone Management Act, 16 U.S.C 1451 et seq. states that "it is the national policy to preserve, protect, develop, and where possible, to restore or enhance, the resources of the Nation's coastal zone for this and succeeding generations;" and, "the protection of natural resources, including wetlands, flood plains, estuaries, beaches, dunes, barrier islands, coral reefs, and fish and wildlife and their habitat, within the coastal zone." Based on the location of the Site, the Coastal Zone Management Act is applicable. The Site will comply with the Texas approved coastal management program, and construction and operation will be conducted in a manner consistent with the program. BP will coordinate with the General Land Office to provide necessary materials required for approval and consistency review.

A Coastal Management Program Consistency Statement per Section 307 of the Coastal Zone Management Act will be prepared. This statement will be submitted with the USACE Section 404 permit application. The USACE will coordinate with the Texas General Land Office and the TRRC, as appropriate, for the requisite consistency determination. The enforceable policies of the Texas Coastal Management Program (31 TAC 15 §501, Subchapter B) will be reviewed to determine the applicable policies. BP will prepare text affirming that the proposed activity, its associated facilities, and their probable effects comply with the relevant enforceable policies of the Texas Coastal Management Program and that the proposed activity will be conducted in a manner consistent with such policies.

13.5 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act, 16 U.S.C. 661et seq., requires the Regional Administrator, before issuing a permit proposing or authorizing an impoundment (with certain exemptions), diversion, or other control or modification of any body of water, to consult with the appropriate State agency exercising jurisdiction over wildlife resources to conserve these resources.

In accordance with the Fish and Wildlife Coordination Act, the presence of these types of streams or other bodies of water will be determined within the areas that may be impacted by activities associated with the Site. If required, proper permits and authorizations will be acquired prior to construction and operation of the Site.

13.6 Environmental Justice

EPA considers environmental justice in its review of Class VI injection well permit applications. Environmental Justice is defined in Executive Order 14096[34] (Revitalizing Our Nation's Commitment to Environmental Justice for All) as the "just treatment and meaningful involvement of all people, regardless of income, race, color, national origin, Tribal affiliation, or disability, in agency decision-making and other Federal activities that affect human health and the environment so that people: (i) are fully protected from disproportionate and adverse human health and environmental effects (including risks) and hazards, including those related to climate change, the cumulative impacts of environmental and other burdens, and the legacy of racism or other structural or systemic barriers; and (ii) have equitable access to a healthy, sustainable, and resilient environment in which to live, play, work, learn, grow, worship, and engage in cultural and subsistence practices."

BP used the federal EJ screening tool, EJSCREEN, to evaluate communities within the AoR that potentially could be adversely and disproportionately affected by human health, environmental, climate-related, and/or other cumulative harms or risks. EJSCREEN indicated that the AoR is "too small or sparsely populated" to support an EJ Screen report. Therefore, no communities with potential EJ concerns were identified in the AoR. When including an additional two-mile buffer around the AoR, EJSCREEN identified a population of one, and all of the state screening indicator results were less than the 80th percentile. Therefore, disproportionately high adverse impacts on minority or low-income populations near the Site are not expected as a result of permitting the Class VI injection wells at this particular location.

In connection with the broader activity addressed by BP's participation in CarbonSAFE Phase III, which is inclusive of the West Bay Storage Facility Class VI injection well activities, BP developed a Community Benefits Plan (CBP) that has been accepted by the U.S. Department of Energy (DOE). BP will engage community stakeholders in areas relevant to the proposed Justice40 mitigation measures outlined in the CBP, which will consist of creating clean energy education and workforce development programs.

[34] https://www.federalregister.gov/documents/2023/04/26/2023-08955/revitalizing-our-nations-commitment-to-environmental-justice-for-all

ATTACHMENT 1
GEOCHEMICAL MODELING AND SIMULATION RESULTS